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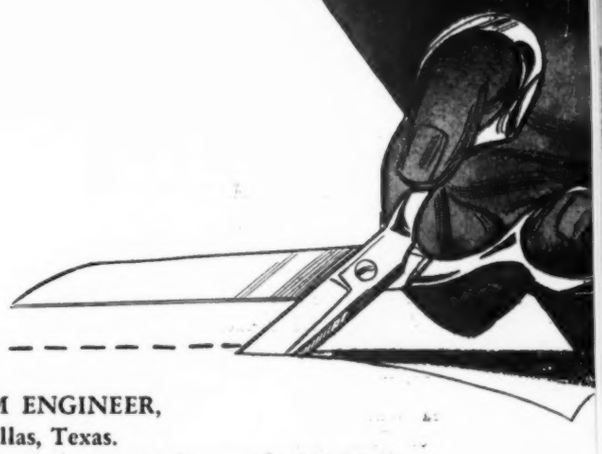

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FEBRUARY 1939 • THE *Petroleum* **Engineer** • VOLUME X NUMBER 5

Published by THE PETROLEUM ENGINEER PUBLISHING COMPANY . . Telephone 2-4571 . . Seventh Floor Allen Building . . DALLAS, TEXAS

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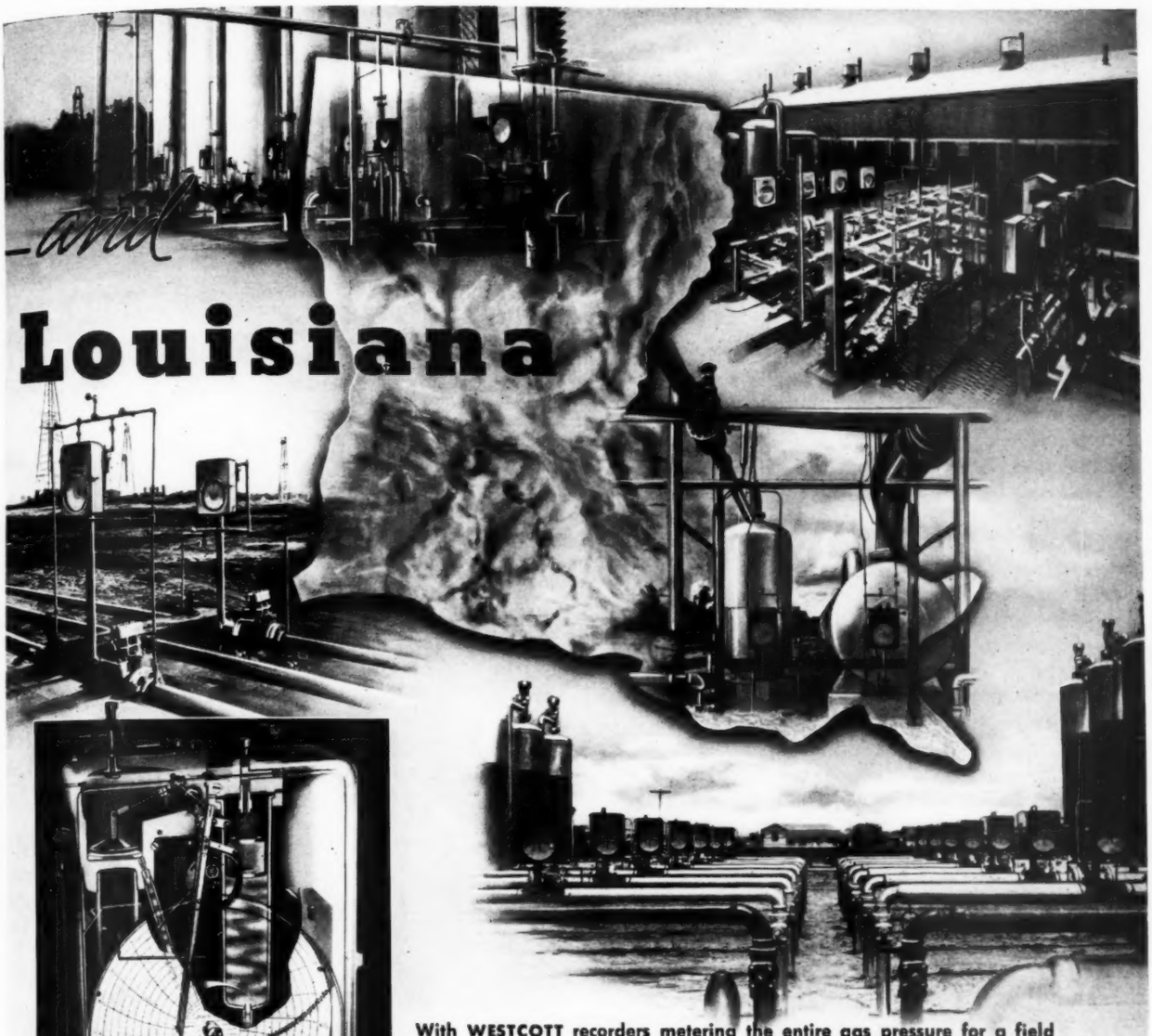

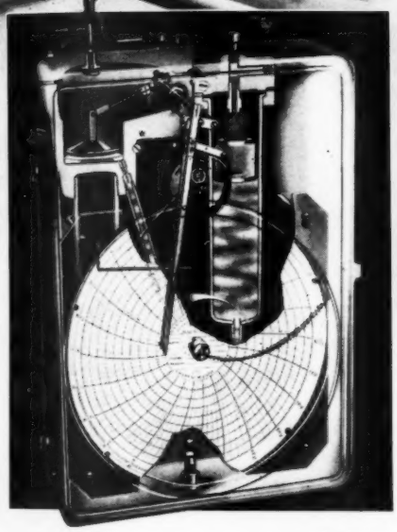

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The Course of Oil

By K. C. SCLATER

Condensate Wells Classified

Legal considerations have necessitated a stricter classification of wells in Texas. A hybrid type of well—one that has defied classification either as a gas well or oil well—has been developed in relatively large number in Texas in the last few years. These wells have been termed "distillate" or "condensate" wells because they produce highly volatile liquids at high gas-liquid ratios. State conservation regulations, recognizing only two types of wells, gas wells and oil wells, were found inadequate when applied to these hybrid wells.

Field investigations have disclosed that wells producing such products as are termed "condensate" or "distillate" are, with few if any exceptions, wells from which liquids are obtained at the surface. Such liquids are in the gas phase in the reservoir and are formed by the decrease in temperature and pressure that occurs after the gas leaves the reservoir and during its rise in the well on its way to the surface. Such wells have been termed condensate wells.

In classifying condensate wells the Commission order states that all wells in Texas that produce hydrocarbon liquids that are condensation products from a gas phase are classified as gas wells; that all wells producing hydrocarbon liquids, a part of which is formed by condensation from a gas phase and a part of which is crude petroleum, shall be classified as gas wells, unless there is produced one barrel or more of crude petroleum per one hundred thousand cubic feet of natural gas. By crude petroleum is meant hydrocarbons in the liquid phase in the reservoir.

Wells in this classification generally produce from reservoirs at great depth and high pressure.

This classification is a reasonable one that clarifies a moot point that has become increasingly important. It seems to fulfill its purpose in bringing conservation regulations into line with technological progress, by recognizing as a basis the physical state of the hydrocarbons in the reservoir at the time of discovery. The provision that a well be classified as a gas well, unless it produces one barrel or more of crude petroleum—that is, crude petroleum as that term is generally known in the industry—per hundred thousand feet of gas, reduces the possibility of confusion regarding whether, according to state regulations, a well is a gas well or an oil well.

Dead Well Subterfuge

The well being the proration unit in the East Texas field, the greater the number of producing wells on a lease the larger the production allowed that lease. As the number of wells in the field increases, the allowable production per well suffers. If a well goes "dead," failure of that well to produce deprives the lease of that well's allowable production.

Because of the small well allowables now prevailing in the field, various subterfuges are resorted to by the unscrupulous operator in an effort to escape the penalty of a dead well and obtain a high lease allowable. Asserted to be one of the most prevalent of these is that of reporting to the Railroad Commission dead wells as producers.

Because of the size of the field and the expense involved, it has been difficult to check this practice. Doubtless some of these "dead" wells could be revived and made to produce; but this may entail an expense that the operator sees fit to dodge or refuses to incur.

This practice may be on the way out; at least there is evidence that some progress is being made toward its eradication. A total of 98 dead wells reported as active were found and removed from the East Texas proration schedule during January.

A drastic measure designed to put a stop to this malpractice is seen in a bill recently introduced in the State legislature. This bill would make it a felony to retain a dead well on a production report, and proposes a heavy fine and prison sentence for obtaining allowable oil production in violation of State proration regulations. Not only would the bill apply to dead wells, but also to wells that can not make their allowable.

A stricter enforcement of regulations in regard to dead wells would benefit the majority of operators in the field. Well allowables would be higher and reservoir pressures more uniform.

More Effective Proration

In presenting a design for more effective proration before the American Institute of Mining and Metallurgical Engineers at their annual meeting in New York this month, Joseph E. Pogue, noted oil economist, says that the individual oil pool should be restricted according to its most efficient rate of production. In other words, the basis for prorating an oil pool, as has been repeatedly advocated in this column, should be reservoir conditions. Making the individual well the ultimate unit of proration places a premium on the drilling of unnecessary wells. The proper unit, it is pointed out, is the available oil in the individual property.

A wider recognition of these facts by administrators of proration would go far toward the correction of the existing trend toward over-capitalization of producing facilities. Effective proration requires the ability to expand reserves without encouraging their premature development by wells in excess of market requirements.

Proration has changed the economics of oil production. It has brought about a system of delayed production, but the system of drilling still lags far behind the new trend. Drilling programs adapted to the needs of the old rule of capture whereby wells were produced at their maximum capacity have become obsolete under the system of delayed production. A modification of drilling practices, therefore, to conform with this system, it is pointed out, offers the means for harmonizing investments with delayed returns. Were these changed conditions given more consideration and recognition by producers, the drilling of many unnecessary wells, particularly in proved fields, would be eliminated.

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« « HIGHLIGHTS IN OILDOM » »

Pennsylvania Crude Oil Prices Advance

Prices of Pennsylvania grade crude oil advanced on February 1 for the second time in 1939. The first advance was made January 21. Both advances were announced by the Joseph Seep Purchasing Agency of the South Penn Oil Company. The new prices are: Bradford and Alleghany districts, $1.88, an increase of 8 cents a bbl.; Southwest, $1.53, an advance of 10 cents; Eureka, $1.47, an increase of 10 cents; Buckeye, $1.45, an increase of 14 cents; and Corning, $1.02. The January 21 advance ranged from 9 to 12 cents a bbl., and the February advance from 8 to 15 cents.

●

Kansas Would Save Stripper Oil Wells

Kansas' new governor, Payne N. Ratner, believes the state's stripper oil wells should be saved and his initial step in that direction has been the appointment of an oil advisory committee to investigate the problem. On the committee he has named Ralph Pryor, Wichita, independent operator, chairman; John Denman, Independence; D. R. Lauck, R. W. Pyle, and Joseph Aylward, all of Wichita; Ward McGinnis, Eureka; C. D. Kerr, Ellinwood, Stanolind Oil and Gas Company; Max Mahaffey, Eldorado, Cities Service Oil Company; and Fred Mallonee, Wichita, White Eagle Oil Company.

"The oil industry is second in importance only to agriculture in Kansas," Governor Ratner said, "but profits of the oil industry have declined and its development has slowed down. The 'stripper' area, in eastern and southern Kansas, faces possible destruction and the total loss of this valuable natural resource. Certainly, the state should make every effort to prevent such destruction."

●

Argentina Crude Oil Production Increases

Production of crude oil from state oil fields in Argentina totaled 18,999,167 bbl. in 1938, compared with 17,937,952 bbl. in 1937, an increase of 13.36 percent. Dr. Ricardo Silveyra, president of the Y.P.F. (state oil fields), predicts that additional pipe line, refining, and storage facilities will result in the doubling of the output from the Salta area in 1939. The government recently authorized the Y.P.F. to construct a new refinery at La Plata, which will cost approximately $2,450,000.

●

Mexico Places One-Eighth Value on Oil Properties

The Mexican Finance Minister, Eduardo Suarez, on February 9, officially advised dispossessed American and British oil companies that the Mexican Government had completed its evaluation of their expropriated properties. Suarez withheld the estimates of the government survey, but associates said they would not exceed 250,000,000 pesos, or approximately $50,000,000. Oil men value the properties at $400,000,000. The inventory covered only surface properties.

●

Condemn Aggressive Transfer of Allowables

A resolution condemning aggressive transfers of allowables was passed by the Central Committee of California Oil Operators at a recent meeting in Los Angeles. Final vote on the resolution, introduced by Ross McCollum, member of the Central Committee and of the Emergency Executive Committee, favored its passage three to one.

An aggressive transfer of allowable is the practice of shutting-down oil production from a low-gravity field of low output and then taking credit for that amount of production from a higher-gravity, more prolific and profitable field. This practice has made it possible for certain companies to shut-down production in one field and over-produce in others, but by taking credit for the allowable of the shut-down wells, still to show an over-all picture of compliance with the company allowable figures set up by the State Oil Umpire's office.

The Central Committee, which has the responsibility of administering California's voluntary oil curtailment program, has never formally approved the practice, which has gradually grown during the last few years, but until the recent meeting, had never formally disapproved it.

Condemnation of aggressive allowable transfers has been general throughout the industry for some time, and has been outspoken since the Emergency Executive Committee started its present drive for curtailment during the over-production crisis facing the industry.

●

Seek Extension of Compact Law in Kansas, Texas

Governor Payne H. Ratner has asked the legislature to extend for two years the authority to continue Kansas' membership in the Interstate Oil Compact Commission. The present law, under which the governor is authorized to enter into agreement with other states in the solution of problems pertaining to the oil industry, will expire next September.

In his message to the legislature, Governor Ratner said in part: "Kansas will thus be in a better position to work towards the solution of the many troublesome problems which confront the entire oil industry, to conserve the abundant, life-giving resources now found in almost every section of the state, and thus work for the general economic good."

At almost the same time, Senator Penrose B. Metcalfe, San Angelo, introduced a bill before the Texas Legislature to extend for two years that state's participation in the Interstate Oil Compact Commission, dating also from next September.

●

Appeals Court Renders Decision On Rule 37

The Third Court of Civil Appeals of Texas has affirmed in part and in part reversed and remanded a lower court judgment on Rule 37, the spacing rule, in a case styled Railroad Commission vs. Magnolia. The suit arose over an 0.86-acre tract awarded to Herman Castleberry (Christian) in a partition suit, to which Greer acquired a lease. The court said in part:

"Much of the appellant's brief is devoted to the assertion that partition in kind is a vested right and Herman was entitled as a matter of law to develop the tract independently of the 25-acre tract. This assertion is contrary to the uniform holding of this court and the Supreme Court.... The tract falls squarely within the voluntary subdivision rule, and in determining the validity of the Commission's order, the segregation must be disregarded.

"We hold that the court must be upheld under the decision in the Century case as interpreted by this court: Where, independently of the vountary segregation, the larger tract is entitled to an additional well to protect vested rights the permit to drill on the segregated tract will be upheld, although contested by the owners of the remaining portion of the larger tract.

"In effect, the Century decision holds that where the larger tract is entitled to an additional well to protect vested rights, the Commission's order is not reviewable by the courts, regardless of the point on the tract at which the Commission may locate the well."

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Major Pipe Line Activities

THE Shell Pipe Line Company has begun surveys for an 8-in. pipe line from the fields in Gaines and Yoakum counties to its terminal at Hobbs, New Mexico. The Humble Pipe Line Company line now serving the area has become congested by the rapidly increasing production of the Denver, Wasson, and Bennett fields, and can accept only 85 percent of present field allowable production.

●

The Louisiana-Nevada Transit Company, represented by its president, W. A. Delaney of Ada, Oklahoma, has contracted with The Arkansas Portland Cement Company to supply 10,000,000 cu. ft. of gas per day from the Cotton Valley field, Louisiana, to the Okay, Arkansas, plant of the cement company. A 75-mile, 8⅝-in. line will be constructed.

●

The Pan American Pipe Line Company has agreed to accept 6000 bbl. of crude oil per day from the Cayuga field, Texas, beginning about February 15, provided the producers accept a somewhat reduced price comparable to that paid for Talco, Smackover, and other similar oils, because it will be necessary for the pipe-line company to install different equipment in its refinery at Texas City in order to process oil of this type. The oil producers have already indicated their acceptance of the conditions.

●

The Illinois Pipe Line Company has awarded contracts to the Sheehan Pipe Line Construction Company and the White Deer Pipe Line Construction Company to lay a total of 212 miles of 8-in., 10-in., and 12-in. loops to the company's trunk system in Illinois, Indiana, and Ohio.

The Sheehan company will lay 127 miles of 10-in. pipe and 31 miles of 12-in. Three crews, each composed of 100 workmen, will be employed simultaneously, laying loops from Jamestown, Indiana; Rockwood, Ohio, and Elwood, Indiana, which, when completed, will transport crude oil from Mid-Continent and Illinois fields to the Standard Oil Company's refinery at Lima, Ohio, and to other eastern refineries.

White Deer will lay 54 miles of 8-in. line.

The electric welding contract on both jobs has been let to the H. C. Price Company.

These loops will facilitate the movement of Mid-Continent and Illinois crude through the Illinois Pipe Line Company's system as well as an increased volume from the Central Coal Basin area of Illinois.

No new pumping stations will be required.

●

The Pacific Gas and Electric Company, San Francisco, California, will lay an 8-in. gas line from Marysville to Lincoln, California, a distance of 36 miles, it has been announced. The line will extend from Marysville across the Yuba and Bear rivers to Wheatland and to Roseville where it will connect with the company's Rio Vista trunk system. The principal reason for laying the line is to supply gas to the Gladding-McBean Pottery at Lincoln, although gas also will be supplied consumers in Lincoln, Wheatland, Roseville, and possibly Auburn, Grass Valley, and Nevada City. The gas supply is obtained from the company's wells in the Sutter Buttes area.

●

The 22-mile, 6-in. gas pipe line laid by the Southern Union Utilities Company, Dallas, Texas, from the Tomball field, Texas, to Prairie View, has been completed and placed in operation. Contractors for the construction of the line were Dixon and Horton, Longview, Texas, and H. C. Frizzell, district manager, was in charge for the Southern Union.

●

The General Gas Pipe Line Corporation of Indianapolis, Indiana, has made application to the Federal Power Commission for a certificate of public convenience and necessity authorizing the construction and operation of a 20-in. natural gas pipe line approximately 180 miles in length to transport natural gas from fields in Kentucky, the terminus of the line to be in Indiana. It is also proposed by the applicant to lay about 40 miles of 3-, 4-, 6-, and 8-in. gathering lines.

A War Department permit has been obtained for the construction of a double line across the Ohio River near Louisville, Kentucky, the application states, also asserting that one 2400-hp. compressor station would be constructed.

The General Gas Pipe Line Corporation is a new company and its officers are: Albert Kalo, Indianapolis, Indiana, president and chairman of the board of directors; Elmer E. Boone, Whiteland, Indiana, vice-president and assistant general manager; Ethyle Fahrson, Indianapolis, secretary; Chelsea C. Boone, Elkhart, Indiana, treasurer; and Irene Kalo, Indianapolis, assistant treasurer.

●

The Public Service Gas Company, Minneapolis, Minnesota, has made application to the Federal Power Commission for a permit to construct a 1500-mile gas line from Montana and Wyoming fields to North Dakota, South Dakota, Minnesota, and Wisconsin.

●

Announcement has been made that work will begin soon on the construction of a high-pressure pipe line 60 kilometers in length having a daily capacity of 10,000 cu. meters of gas to transport natural gas from the recently discovered field at Pietramala in Tuscany, Italy, to Florence.

Special induction and pumping stations will be erected at Pietramala, and it is observed that the functions of the pumping station will be of utmost importance. Difficulties may be encountered as Pietramala is situated 1000 meters above sea level and Florence is but 50 meters above sea level.

At Florence the line will branch and at the terminal of each line supply depots will be erected. A third distributing station may be constructed at the point where the line branches.

The project is expected to be completed by April 21.

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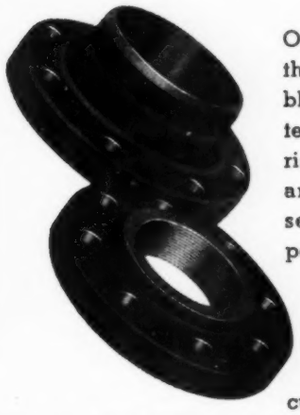

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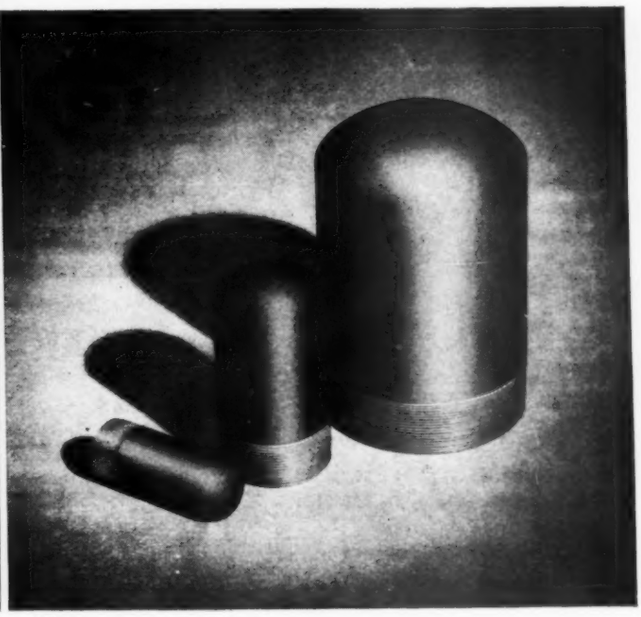


Activities In The Oil Fields

COYLE-CONCORD Oil Company's No. B-4 O. M. Powell, in the Garwood gas field, Colorado County, Texas, produced at the rate of 3 bbl. of 40-deg. gravity oil per hour from the Pettus zone at a depth of 5922 to 5930 ft. through 3/16-in. choke. Casing pressure was 1800 lb. and tubing pressure, 1200 lb. This is the first well in the field to yield oil in commercial quantity, although Plymouth Oil Company's No. 1 Reams, drilled in 1933, produced some oil from the Cockfield at a depth of 6192 to 6203 ft.

●

Easterwood and Cage's No. 1 Mrs. Kate Dunn, in the Manuel Flores Survey, San Patricio County, Texas, one and three-fourths miles west of the East White Point oil field, and on the east flank of the White Point gas field, flowed 5 bbl. per hour on a 15-hour test through a ⅛-in. choke from a sand at a depth of 5672 to 5676 ft. Casing pressure was 400 lb. and tubing pressure, 375 lb. The well seems to open a small new pool rather than to extend the East White Point field.

●

Sid Richardson's No. 1 Haas, in section 7-2s-3e, near Eola, Avoyelles Parish, Louisiana, recently completed in the Sparta-Wilcox zone, attracted considerable attention to the prospect of obtaining production from that zone in other areas, particularly along the Angelina-Caldwell flexure in central Louisiana. Farther west, Kirby Brothers' No. 3-B Kirby-West, in the Ace (Schwab) field, Polk County, Texas, yielded 450 ft. of 35-deg. gravity pipe-line oil in a 15-minute drill-stem test of the same sand at a depth of 7749 to 7755 ft. Wells previously completed in the field produce from the Cockfield formation. The Segno field of Polk County produces from the Wilcox formation.

●

Carl Robinson's No. 1 Walter Felix, in SW SE SE of 27-2s-8e, eight miles south of Fairfield, Wayne County, Illinois, and two and one-half miles from nearest production, flowed as the cement plug was being drilled by a bit on the end of 2-in. tubing. The well, flowing through the bit equivalent to about a 1½-in. choke, produced 210 bbl. of 40-deg. gravity oil in a 5-hour test, and casinghead pressure was 200 lb. Gas production was estimated to be 1,000,000 cu. ft. The 5½-in. casing is set at a depth of 3379 ft. Total depth is 3409 ft. McClosky limestone was cored from 3385 to 3402 ft.

●

The Superior Oil Company's No. 12 KCL, in NE of section 3-30-26, three miles southeast of the Greeley field, California, found 70 ft. of good oil sand. The sand, which is believed to be the Vedder or Rio Bravo, was entered at a depth of 11,120 ft. The well adjoins two dry holes the company had drilled to test the Stevens zone. In drilling No. 12 KCL, which may prove to be a major discovery, a speed record is thought to have been established for wildcat wells, in that the well was drilled to a depth of 11,100 ft. in 60 days.

●

Sunray Oil Company's No. 1 Fleet, in NE SW SW of 12-6n-5e, in the North Grayson pool, Seminole County, Oklahoma, yielded no oil from the Dolomite, which produces oil in three of the other four wells in the pool, so was plugged-back to a depth of 2900 ft. and after being shot with 15 qt. flowed 140 bbl. of oil in 24 hours through casing, thereby opening a new producing zone in the field. The fifth well in the field produces from the Wilcox formation.

●

G. Scott Hammond's No. 1 Ford, in the Rodessa area about two and one-half miles northeast of the Lodi district, Marion County, Texas, produced an estimated 1,000,000 cu. ft. of gas per day from the Henderson zone at a depth of 6023 to 6187 ft. Casing was set at a depth of 6007 ft. and the well was treated with 1500 gal. of acid.

AVERAGE CRUDE PRICES

California	
Kettleman Hills	$1.19-1.43
Playa Del Rey	.80-1.16
Coalinga	.70- .90
Signal Hill	.80-1.21
Montana	.90-1.10
Wyoming	.35-1.30
Colorado	.90- .98
New Mexico	.77-1.00
Texas	
North Central	.71-1.03
Panhandle	.67- .96
West Texas	.53- .95
Gulf Coast	.79-1.28
Darst Creek	.96
East Texas	1.10
Talco	.55
Kansas	.60-1.10
Oklahoma	.60-1.10
Arkansas	.73
Louisiana	
Rodessa	$ 1.05
Gulf Coast	.74-1.20
North Louisiana	.73-1.05
Illinois	1.05-1.15
Kentucky	1.10-1.20
Indiana	1.05
Ohio	
Lima	.90
Michigan	.70-92.5
Pennsylvania	
Bradford	1.88
Southwest	1.53
Eureka	1.47
Buckeye	1.45
Corning	1.02
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in Barrels)

	[1]B. of M. Calculated Requirements (February)	Week Ended Feb. 4, 1939	Week Ended Dec. 31, 1938	Week Ended Feb. 5, 1938
Oklahoma	482,500	422,000	421,900	533,100
Kansas	148,600	140,150	149,100	179,950
Panhandle Texas		65,900	62,300	55,550
North Texas		87,700	77,850	63,050
West Central Texas		31,850	30,000	26,900
West Texas		239,800	202,500	176,550
East Central Texas		101,700	95,000	89,350
East Texas		447,150	371,850	424,000
Southwest Texas		280,700	229,300	203,950
Coastal Texas		241,150	211,500	179,250
TOTAL TEXAS	1,297,500	1,495,950	1,280,300	1,218,600
North Louisiana		69,400	66,750	80,650
Coastal Louisiana		191,650	187,500	177,350
TOTAL LA.	246,800	261,050	254,250	258,000
Arkansas	48,200	52,350	49,700	41,500
Illinois	102,500	146,700	134,100	(
Eastern (Not incl. Illinois)	94,300	94,650	89,550	(137,250 (
Michigan	47,200	51,650	46,200	48,700
Wyoming	57,100	48,400	46,600	45,150
Montana	12,100	12,800	12,350	14,300
Colorado	3,600	4,000	3,950	4,150
New Mexico	99,600	101,950	98,550	106,050
TOTAL EAST OF CALIF.	2,640,000	2,831,650	2,586,550	2,586,750
California	580,000	610,300	614,900	729,700
TOTAL U. S.	3,220,000	3,441,950	3,201,450	3,316,450

[1]These are Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of February. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

Great Pioneers

TEXAS 1836

March 6th, 1836, the Alamo, in which 183 defenders had taken refuge, fell with the slaughter of every man. It was Sam Houston who resumed active command of the army, after the death of General Fannin, and captured Santa Anna, the Mexican general. Standing alone, Texas faced many difficulties, but it was during this period that it won its independence from Mexico. In 1846, Texas added her own glorious star to Old Glory.

● TODAY, AS YESTERDAY, pioneers are first. As the dictionary puts it, they are men who "go before, preparing the way for others to follow." To this spirit of pioneering leadership the oil industry owes the development of the present Dowell chemical service for oil and gas wells.

Dowell did the seemingly impossible when, in 1932, it perfected and announced Inhibited Acidizing. During these past seven years, thousands of wells have been maintained at profitable production levels, due to Dowell—a tremendous gain to oil producers.

To its original service, Dowell has added numerous basic advances in materials and methods. Thus, its leadership in this vital field is constantly being extended through intensive research, modern technical equipment and a highly trained, experienced and permanent personnel.

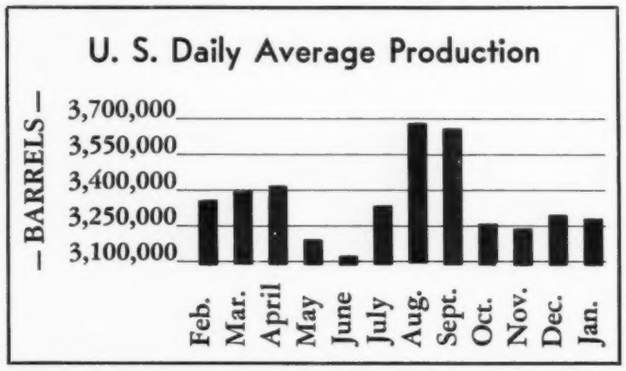
DOWELL INCORPORATED
General Office: KENNEDY BUILDING, TULSA, OKLA.
Subsidiary of THE DOW CHEMICAL COMPANY

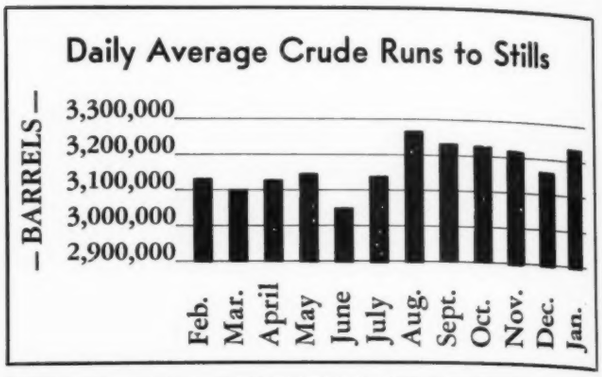
Look to

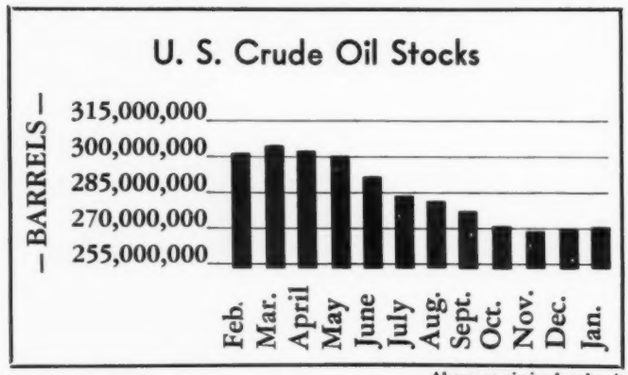
DOWELL

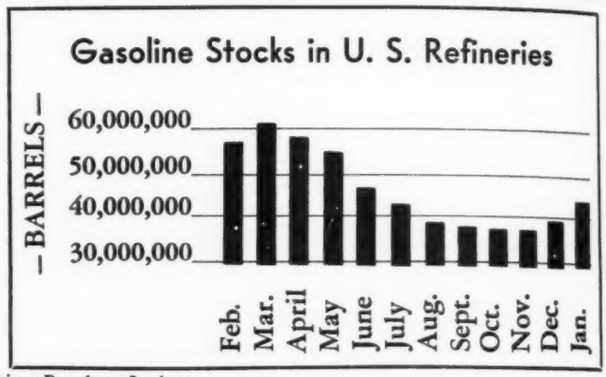
OIL AND GAS WELL
CHEMICAL SERVICE

Petroleum Statistics and Field Activities









Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for January, 1939

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	90	89	14	47	3500-3700	2	40	Rotary
Duval County	58	50	6	20	1554-2900	2	22	Rotary
Ector County	47	47	7	61	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	37	36	30	104	1700-3900	2	40	Rotary
Refugio County	11	11	3	12	4900-5900	2	38	Rotary
Nueces County	27	21	5	13	3922-5878	2 or 3	21-54	Rotary
Winkler County	19	18	5	10	2850-3450	2 and 3	30-38	Rot.-Cab.
K. M. A. Field	30	28	31	45	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Oklahoma City	4	3	2	6	6450-6682	3	39	Rotary
Fitts Pool	11	7	2	4	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	17	15	4	24	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	15	14	2	13	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	13	8	4	17	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	352	263	52	395	2950-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	54	49	10	59	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	....	....	1	6	8300-8730	3 or 4	40	Rotary
Wilmington	6	6	5	10	3500-4000	2 and 3	18-20	Rotary

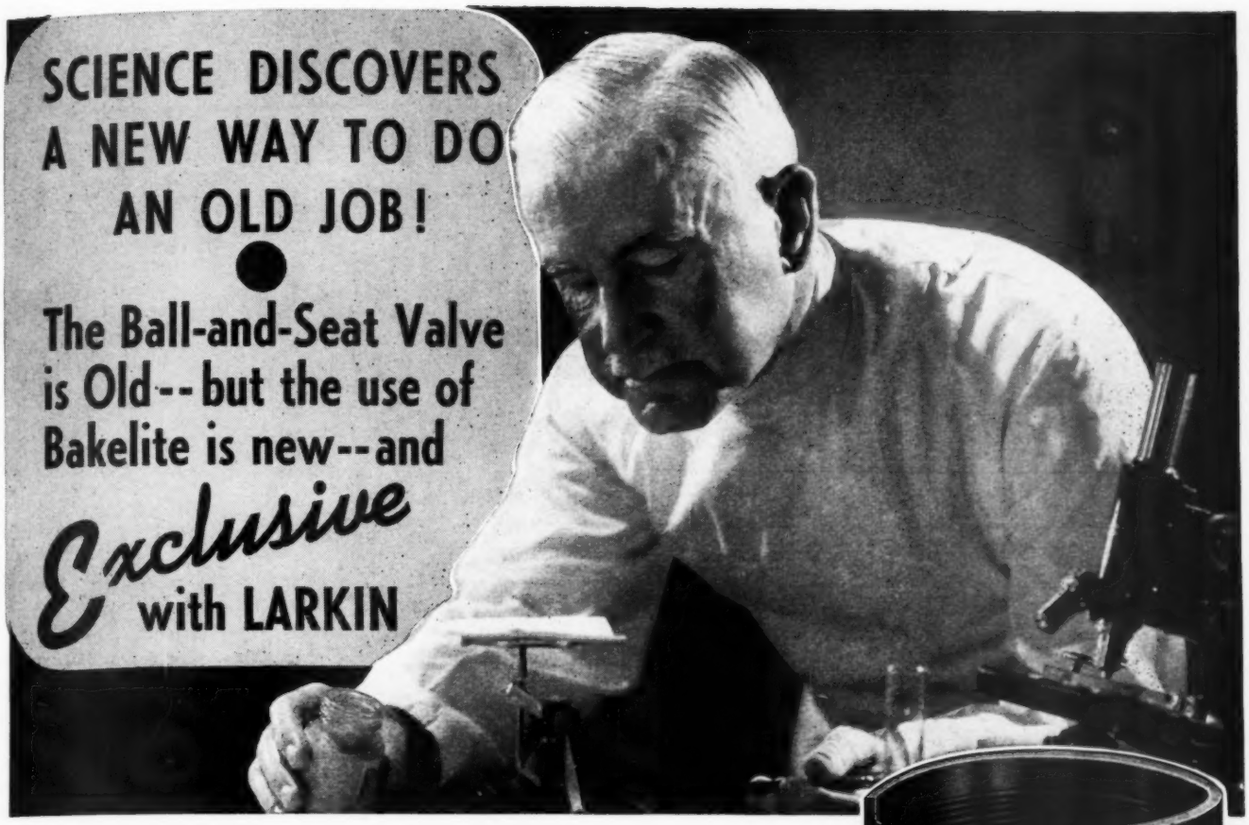
Field Activities by States for January, 1939

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1938 (In Barrels)
	January	December	January	December	January	December	January	December	January	December	
Arkansas	28	28	22	20	20	22	15	14	31	35	18,211,617
California	83	121	71	93	108	88	74	75	156	160	249,918,001
Colorado	2	2	1	1	....	....	2	2	26	28	1,371,687
Illinois	352	452	263	369	....	....	52	47	311	428	23,306,000
Indiana	11	11	6	4	....	....	2	2	35	37	965,900
Kansas	99	114	75	90	139	109	31	25	156	152	58,795,545
Kentucky	69	74	37	50	....	....	6	7	127	130	5,828,650
Louisiana	77	109	51	86	77	95	38	36	175	182	94,941,537
Michigan	84	99	45	59	77	100	21	24	109	108	19,140,966
Mississippi	1	1	0	0	....	....	5	7	1	4	Gas Prod.
Montana	9	6	6	5	....	....	3	2	51	50	4,858,458
New Mexico	59	66	53	62	....	....	12	13	141	139	35,902,263
New York	56*	38*	53*	37*	....	....	....	....	....	....	5,040,600
Ohio	75	81	56	58	....	....	43	44	140	144	3,292,100
Oklahoma	161	172	102	113	170	180	41	43	265	269	171,812,098
Pennsylvania	119*	112*	115*	101*	....	....	....	....	....	....	17,431,500
Texas	923	885	712	696	713	836	204	242	808	978	473,304,662
West Virginia	48	36	38	32	....	....	20	24	109	112	3,700,375
Wyoming	9	21	5	18	....	....	3	5	62	60	19,005,638
Total	2265	2428	1711	1891	1304	1430	572	612	2703	3016	1,206,827,597

*Includes water-intake and pressure wells.

SCIENCE DISCOVERS A NEW WAY TO DO AN OLD JOB!

The Ball-and-Seat Valve is Old--but the use of Bakelite is new--and *Exclusive* with LARKIN



A Ball-and-Seat Type Valve—of genuine Fabric Bakelite—designed by Larkin—in a Larkin-engineered Float Shoe or Collar; there is an achievement!

Note, in Figure 428, the ground-perfectly-round Bakelite ball, which seals perfectly. Note the 25% larger opening entirely through the shoe. Note the 8 inches of concrete over the valve seat, to insure more than ample strength for the back pressure valve.

Note particularly, in this and in all Larkin Floating Equipment, the ever-increasing use of Genuine Fabric Bakelite—the *perfect* impact material for guides and valves, that's obtainable *only* in Larkin Engineered Equipment.

Do you know that Fabric Bakelite has a tensile strength of 7200 lbs., compared with 500 lbs. for concrete; and a compressive strength of 36,000 lbs., as against 3000 lbs., for concrete? No wonder we get far less breakage, fewer complaints and returns with Bakelite than with any other material we've ever used. Yet it's easily pulverized by the drill and circulated out of the hole. We repeat—Bakelite is the perfect material for valves and guides!

And both Larkin Valves—this new Ball-and-Seat Type as well as the original Larkin Poppet Type—are made of Genuine Fabric Bakelite, the super-efficient material that's exclusive with Larkin.

At All Supply Stores

LARKIN PACKER CO., INC., ST. LOUIS, U. S. A.

Fig. 428

LARKIN PACKER CO.

Activities in Refining

Percent Refining Capacity Operated

Western Division, 70.7 Percent **Central Division, 74.3 Percent** **Eastern Division, 79.7 Percent**

THE Atlas Pipeline Corporation, controlled by the Lion Oil Refining Company, has closed its Shreveport, Louisiana, refinery. The plant has a capacity of 12,000 bbl. per day and was taking crude oil from the East Texas, Cotton Valley, Schuler, Lisbon, and Shreveport fields.

•

The Sun Oil Company has entered into an agreement with The Girdler Corporation, Louisville, Kentucky, for the installation of a Girbotol gas purification plant at the Marcus Hook, Pennsylvania, refinery. Eleven million cubic feet per day of refinery gas will be treated for the removal of hydrogen sulphide.

•

The Sinclair Refining Company's refinery at Gladewater, Texas, has been closed down. The plant has a capacity of 4000 bbl. per day and has been in continuous operation since 1931.

•

It is reported that the Producers Refining Company of Shelby, Montana, and the Socony-Vacuum Oil Company have obtained a 72-acre tract just west of Shelby and will soon begin construction of a 2000-bbl. thermal cracking plant capable of producing high-octane gasoline. Bids have been called for and it is expected that actual construction will require about eight months. Crude oil from the Cut Bank and Kevin-Sunburst fields will be processed in the plant.

•

A topping plant is being constructed at Chinook, Montana, by the recently organized North American Refining Company to process West Kevin crude. Tractor fuel will be the principal product manufactured. The company has been incorporated for $50,000 and has for its directors A. H. Dorn, Oscar R. Nevig, and Monte A. Burgess of Chinook; O. A. Nepsted of Ferdig, Harold Haugen of Kevin, Albert Holpen of Shelby, and P. F. Kierdrowski of Hogeland.

James B. Wright, Gladewater, Texas, has begun construction of a refinery at Magnolia, Arkansas. The plant will have a capacity of 2000 bbl. per day.

•

Properties of the McClanahan Refineries, Inc., and Leonard Refineries, Inc., both Michigan companies, have been consolidated. Officers of the new company are: J. W. Leonard, Jr., president; Reid Brazell, vice-president-treasurer; B. M. Jones, vice-president; and Wm. H. Watkins, assistant secretary-treasurer. Brazell is general manager, M. D. Vandelery sales manager, and Robert W. Pollard and E. F. Sondregger superintendents of the Alma and St. Louis refineries, respectively.

The new company is also constructing an ethyl blending plant.

•

The refinery at Spokane, Washington, of the Inland Empire Refineries, Inc., is nearing completion. Crude oil supply will be obtained from the Cut Bank field, Montana. It has been announced that the Glacier Production Company has contracted with the Inland Empire Refineries, Inc., to supply 144,231 bbl. of crude at $1.04 a bbl. for the initial operation of the refinery. A 10-year contract also has been signed whereby the Glacier Production Company will supply crude oil under specific minimum and maximum requirements at a delivered price of 20 cents less than the Mid-Continent price for the rest of 1939, 15 cents less than Mid-Continent prices in 1940, and 5 cents less than Mid-Continent prices for the rest of the contract. These price concessions are being made, it is stated, in order to obtain an immediate outlet for production from the Glacier properties.

•

A recent decree provides for the opening of a credit of 5,000,000 escudos by the Ministry of Finance of Portugal, representing one-third the capital that the State will contribute in the "Sociedade Anonima Concessionaria de Refinacao de Petroleos em Portugal (Sacor)", which is the official name of the company to which a charter was granted last May for refining oil in Portugal.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ending February 4, 1939

A.P.I. Figures
(Figures in Barrels of 42 Gal. Each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	477,000	77.6	18,359	10,001
Appalachian	85.9	100,000	78.1	3,171	770
Ind., Ill., Ky.	89.5	429,000	83.5	13,383	6,421
Okla., Kans., Mo.	81.6	241,000	70.5	7,252	4,293
Inland Texas	50.3	109,000	68.6	1,877	1,939
Texas Gulf	89.5	750,000	83.8	10,642	9,298
La. Gulf	97.3	110,000	75.9	2,503	1,659
No. La. & Ark.	55.0	40,000	72.7	431	887
Rocky Mt.	54.2	50,000	78.1	1,581	684
California	90.0	472,000	63.4	14,840	98,427
Reported	85.8	2,778,000	75.9	74,039	134,379
Estimated Unreported		362,000		5,110	3,210
*EST'D TOTAL U.S. FEB. 4, '39		3,140,000		79,149	137,589
*EST'D TOTAL U.S. JAN. 28, '39		3,235,000		77,279	139,349
U.S. B. of M. *FEB. 4, 1938		**3,149,000		86,788	120,575

*Estimated Bureau of Mines' basis.
**February, 1938, daily average.

P 420.3
P 437.

THE Petroleum Engineer

FEBRUARY, 1939

Casing Used As Drill Pipe to Overcome Heaving Shale

String of 7-in. casing landed and cemented below troublesome body of heaving shale by rotating the casing through it, employing continuous circulation and a cast-iron drag-type bit on the casing

By K. C. SCLATER

DESPITE the progress that has been made in recent years in drilling through heaving shale in Gulf Coastal fields, it is still a paramount obstacle to deep drilling in many potentially productive areas. When heaving shale is encountered in a drilling well there is no assurance that it can be overcome. It may delay or frustrate entirely the successful completion of the well. Being aware of this hazard, operators adopt the most likely means at their disposal to control the heaving shale and thus lessen the probability of serious losses.

In view of the fact that the successful drilling of heaving shale is still one of the foremost problems confronting oil development in the Gulf Coastal region, the dissemination of information on the actual methods used by operators to combat heaving shale is highly desirable.

Many of the methods that have been used are interesting and instructive. One such is that employed on the Pan-American Barnsdall Oil Company's well, Community B-1, Valentine field, La Fourche Parish, Louisiana.

Interest attaches particularly to the mechanical means used to land and cement a string of casing through a troublesome body of heaving shale.

According to available information the status of the well at the time the trouble with heaving shale was encountered was as follows: The hole had been cased with 210 ft. of 16-in., 38-lb. spiral-weld surface pipe and 1865 ft. of 10¾-in., 40.5-lb. casing.

Hole had been drilled with 4½-in. drill pipe to a depth of 8160 ft. leaving 6295 ft. of open hole below the shoe of the 10¾-in. casing. Between 8133 ft. and 8150 ft. heaving shale was encountered. Drilling became difficult. The hole would fill with shale to about 7900 ft. causing the circulation to be lost and the drill pipe to become "logy" and have a tendency to stick.

Beginning with the January, 1939, issue of *The Petroleum Engineer* each feature article carries one or more index numbers for the convenience of those who wish to file petroleum engineering literature and data according to the Uren Decimal System, the third installment of which begins on page 77 of this issue.

This difficulty called for immediate action on the part of the operator. A decision was made to set the casing by rotating through the shale.

Before the drill pipe was pulled the mud in the hole to a depth of 7900 ft. was thoroughly conditioned. When the shale began to heave, the drill pipe was run only to this depth (7900 ft.). There was fear it might become permanently stuck, or "frozen," if run below this depth.

After the mud in the hole was thoroughly conditioned to a depth of 7900 ft. the drill pipe was pulled and preparations begun immediately to run the casing.

Nine hours later the first joint of 7-in., 28-lb. Grade D, range 3, casing was run in the hole. It was equipped on the bottom with a cast-iron shale bit (see accompanying illustration), each of the two blades of which was made in two sections to facilitate milling-out and drilling-up. No float equipment was used in the casing string. The mud entered the casing through the water-courses of the bit. As a precaution against backing-out, the collars of the bottom ten joints were welded.

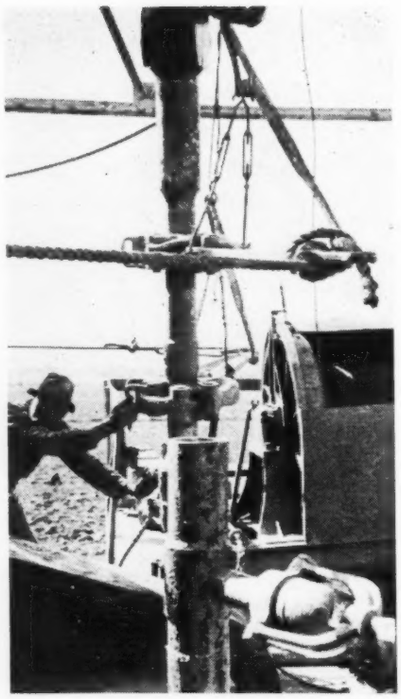
Casing was run in the usual manner to a depth of 7790 ft. At this point circulation was established and the mud

in the hole reconditioned. During the time the mud was being circulated the casing was slowly rotated. For this purpose the rotary table was equipped with liners for the casing slips. Reconditioning of the mud took 45 minutes.

It was decided to use continuous circulation while running the rest of the casing. Continuous circulation was made possible by the use of a special circulation joint, equipped with a built-in flapper-type check valve and a connection on the side of the joint for attaching an auxiliary mud hose. Circulation is maintained continuously while a joint is being added. The check valve, which closes upward, permits pumping mud through the swivel head while the pipe is being rotated, or pumping mud through the port for auxiliary mud hose on the side of the circulation joint and below the check valve. When mud is circulated through the auxiliary mud port, the check valve closes upward, and permits adding a joint of pipe without interrupting circulation. Circulation is thus continued while the swivel is being made up to another circulation joint or sub on top of a new stand of pipe in the rat-hole.[1]

As there were no circulation joints, or subs, immediately available to fit the 7-in. O.D. Extreme Line casing being run in the well, it was necessary to lower the casing string the remaining depth by adding drill pipe, circulation joints for which were available. This necessitated the use of a safety joint, which was screwed into the top casing joint. This joint is made in two parts, joined by a coarse square thread and having a saw-tooth ring and soft metal gaskets at both shoulders (see accompanying sketches). The joints on the saw-tooth ring are tight when rotated clockwise, but can be "broken-

[1]For a detailed description of continuous mud circulation the reader is referred to *The Petroleum Engineer*, March, 1936, p. 28.

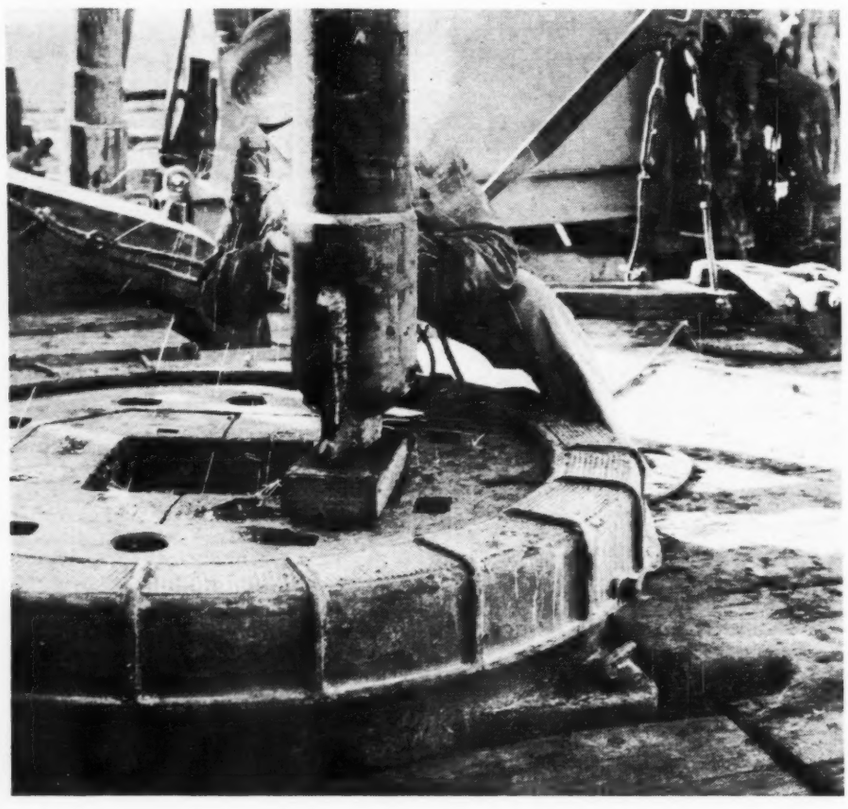


Auxiliary mud hose connected to tool joint sub for circulating while another joint is being added

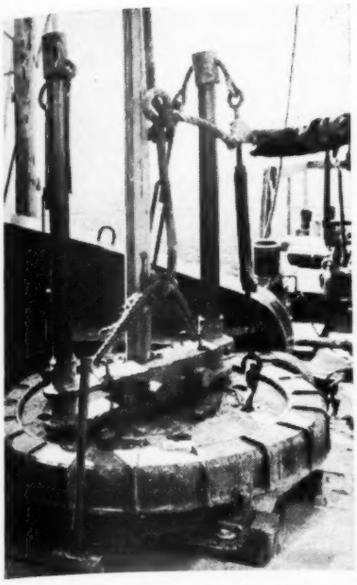
out" by turning counter-clockwise at only about one-fifth the torque required to loosen a taper joint. By using this joint the drill pipe run above the casing could be pulled later and the rest of the casing, provided with a sub similarly threaded, run into the hole to connect into the lower half of the safety joint.

To rotate and still allow the casing to be worked up and down, it was necessary to rig-up a device of some sort. This consisted of two vertical rods, which were attached to the rotary table, and on which a yoke or spider could slide up or down. The spider was carried on the pipe by slips that fitted tightly against the drill pipe, the vertical arms and pipe thus rotating with the table. Vertical movement of the pipe while rotating was obtained by a line attached to the spider and operated from the cathead. Turnbuckles attached to caps on the vertical rods and hooked to the rotary table were employed to prevent the vertical rods from jumping out of the rotary table. The rope and hook shown in the accompanying illustration were used simply to support the extensions while the slips were being tightened. As the table slips were satisfactory and prevented slipping beforehand, this apparatus was used only for lowering the last length of pipe. Wedges driven to hold the slips tight were loosened for a new trip as the spider on the vertical rods worked down to the table.

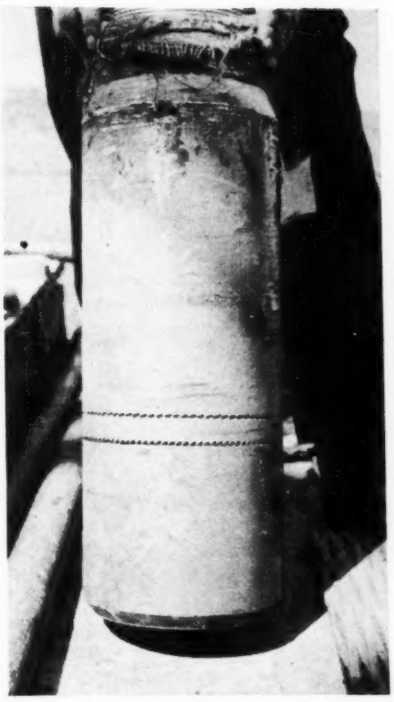
Six double lengths of 4½-in. drill pipe equipped with full-hole tool joints were added. The casing string was worked up and down and rotated without losing circulation and the mud pump pressure was 1500 lb. per sq. in. It is reported that the first five lengths went down with little difficulty to 8110 ft. As the last length of pipe was added and the zone of heaving shale—and also unconditioned mud—was reached, the casing began to show signs of sticking. This was registered on the weight indicator, which showed, on the upward pull, an excess of some 18,000 lb. over the calculated weight



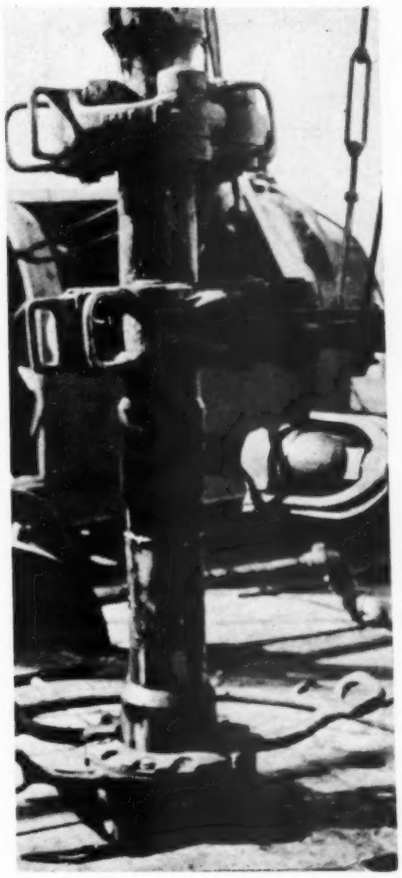
Cast-iron fishtail shale bit made-up and welded to the bottom joint of 7-in. casing



Device used to allow moving the casing string up and down while rotating



Safety joint threaded male and female for 7-in. Extreme Line casing



Swivel being tonged loose after rotating

of the casing and drill pipe. It was observed that the weight was not easing-off and that the torque was increasing. The heaving shale having been passed through, it was deemed advisable to cement the casing. Some 50 ft. of the last length of pipe was lowered very slowly to 8162 ft.; the time taken was 4 hr. and 10 min., an average of 15 ft. an hr. The total depth before running the casing was 8160 ft., so two ft. was made by the bit on the casing.

The average speed of rotation was between 60 and 70 r.p.m.

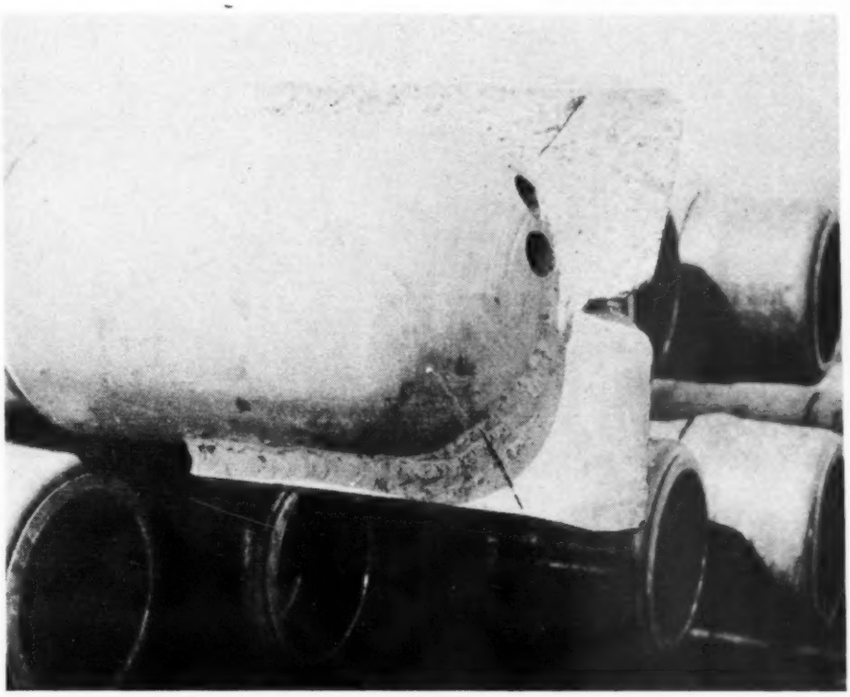
During the running of the last 200 ft. the casing was worked up and down only a few feet. It was thus worked down gradually by observing the load on the weight indicator. The slow downward movement of the casing was continued until the load on the weight indicator began increasing rapidly; similarly, the upward movement was continued until the load began increasing rapidly.

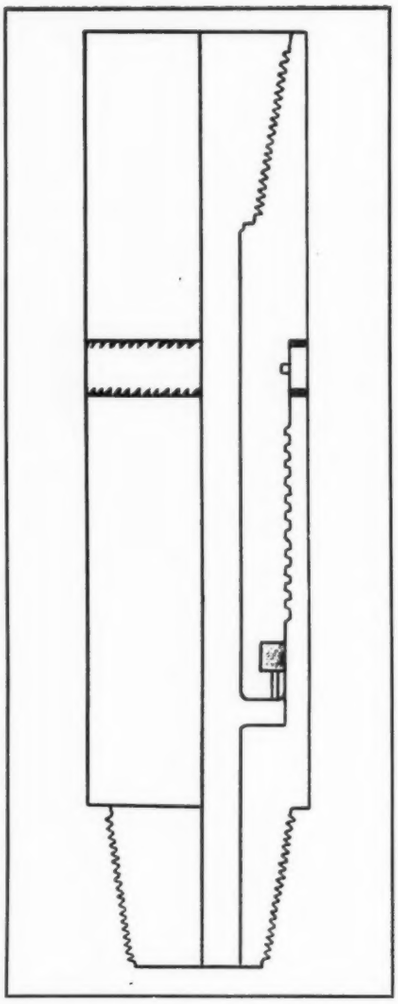
As will be seen from the log, the longest time taken to lower the casing any part of the last 372 ft. by the drill pipe was the 4 hr. and 10 min. required to lower the last 50 ft.; the shortest time taken was that for the second double length, which took 50 min.

A complete log of running the 7-in. casing in this well is presented on the following page.

The 372 ft. of 4½-in. drill pipe on top of the casing string in the well was subsequently pulled by backing-off at the safety joint. In running the remaining 7-in. casing, 2-in. pipe was run inside it, protruding several feet below the sub on the bottom joint of 7-in. that screwed into the safety joint.

Close-up of cast-iron fishtail shale bit. Note the sectional construction of blades to facilitate milling-up and drilling-out





Sketch showing details of safety joint

Running First 193 Joints

Time	Total no. of jts.	No. jts. per hr.
Started 4 p. m.		
5 p. m.	10	10
6	36	26
7	67	31
8	100	33
9	127	27
10	149	22
11	166	17
12	180	14
1 a. m.	193	13

Total time to run 193 joints—9 hr. (includes delays to weld joints, etc.)

Total footage of 193 joints—7790.

Avg. no. of joints per hr.—22.

Avg. no. of ft. per hr.—866.

Connected for continuous circulation—1 a. m. to 1:45 a. m.—45 minutes.

Circulated and rotated casing till 2:30 a. m. —45 minutes.

Rotating and Working-Down Casing by Drill Pipe

Length	Time to connect and lower	Ft. per hr.
1st	2 hr. 10 min.	22
2nd	50 min.	75
3rd	1 hr. 10 min.	53
4th	1 hr. 5 min.	55
5th	1 hr. 10 min.	53
6th	4 hr. 10 min.	15

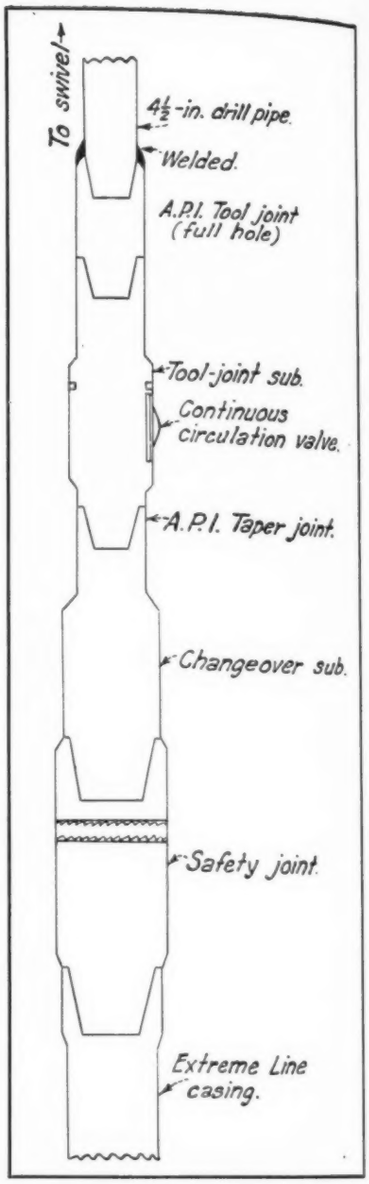
Approximately 11 hr. to lower the casing 372 ft. (7790 ft.—8162 ft.).

Total time from beginning of casing run until cementing was begun—38 hr. including all delays.

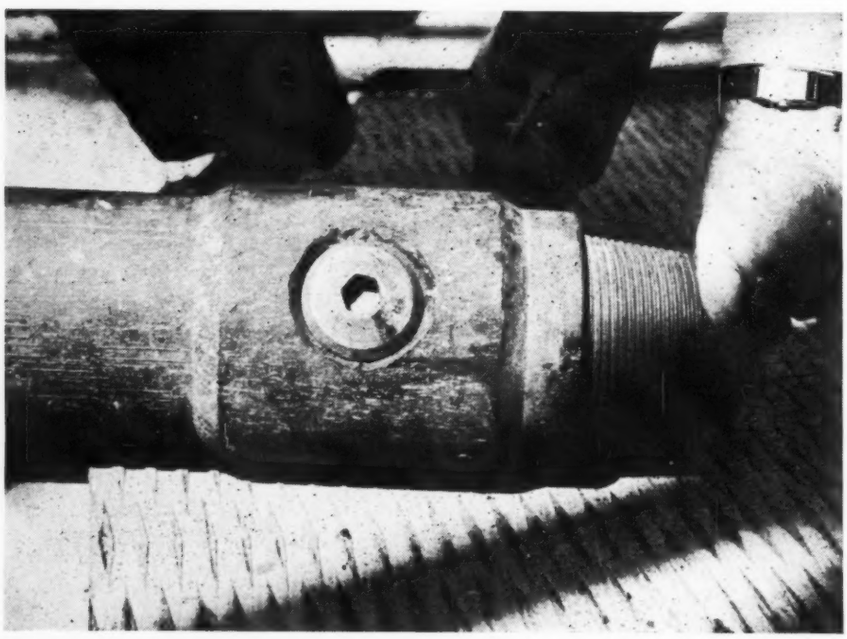
Cementing—1 hr.

Pumping mud—1 hr.

Job completed at 4 a. m.



Details of the connections between casing and swivel for rotating through heaving shale



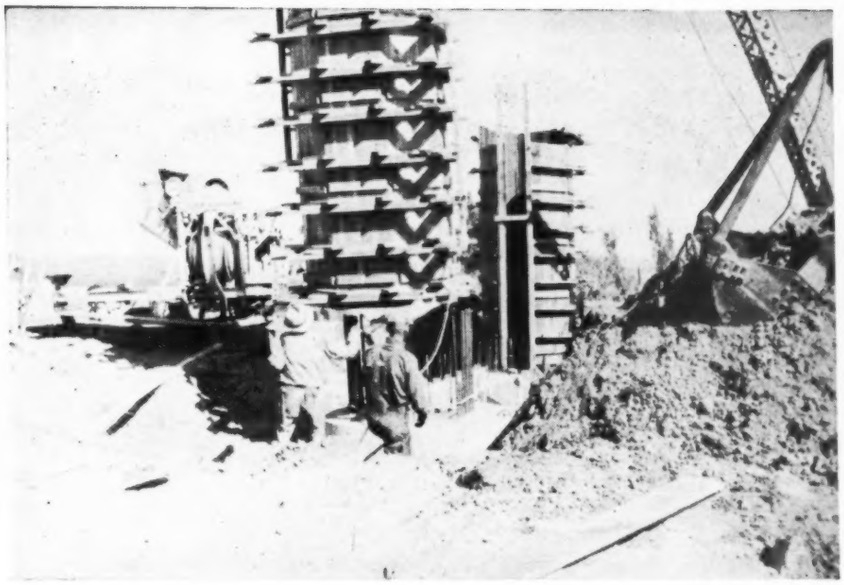
Tool joint circulation sub

The 2-in. acted as a guide in lining-up the lower joint of casing for stabbing and making-up into the lower half of the safety joint on top of the casing in the well.

Drilling of the cement and milling of the cast-iron shale bit was accomplished without difficulty with 3½-in. drill pipe and the well was carried to a greater depth.

The method used in setting 8162 ft. of 7-in. casing in this well is an interesting example of the type of successful mechanical procedure resorted to in overcoming a heaving shale problem in a deep well.

Forms are constructed and equipment is in place for pouring the super-piers



A PETROLEUM ENGINEER FEATURE

Quicksand necessitated adoption of unusual methods in sinking caissons and constructing the main anchors—Other practices employed for first time

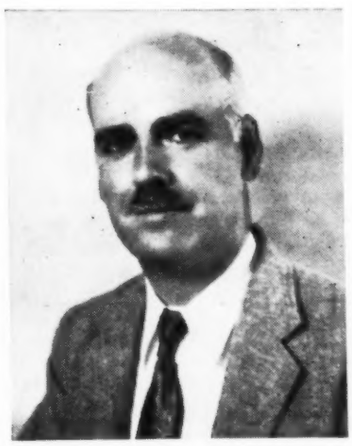
Suspension Bridge Over Red River Replaces Structure Destroyed by Flood

By R. A. MINTER, Office Engineer,
Lone Star Gas Company
as told to
FRANK H. LOVE

IN an isolated area 12 miles north of Hollis, Oklahoma, the Lone Star Gas Company has constructed a pipe-line suspension bridge across Salt Fork of Red River to replace one destroyed last spring when flood waters tore a highway bridge and a railway bridge from their moorings and crashed them against the suspension bridge that supported a gas line transporting natural gas from the Panhandle fields south to Hollis, Dallas, Fort Worth, and neighboring cities and towns. During construction of the new bridge, which required not quite three months to complete, service was maintained by transporting the gas across the river through a 6-in. line laid on the river's bed.

To prevent a recurrence of the previous misfortune the new line, which is of 18-in. diameter the same as the one replaced, is suspended 16 ft. above the record flood level for this particular point in the river. The length of the span is 600 ft. and the distance from anchor to anchor is 1006 ft. On the north side of the river the distance from the main pier to the face of the anchor is 243 ft. and on the south side 163 ft.

Each steel tower is 67 ft. high and is supported by a 14-ft. super-pier and a sub-pier, or caisson. The north caissons extend 50 ft. into the ground and the south, 20 ft. The super-piers are reinforced concrete and the caissons are reinforced concrete contained in a steel shell.



R. A. MINTER

entered the employ of the Lone Star Gas Company in June, 1919, as an assistant engineer supervising field work — Remained until May, 1921, when he went with the Plateau Gas Products Company, Breckenridge, Texas, as engineer and assistant superintendent—Returned to staff of Lone Star in September, 1921, as assistant engineer—From July, 1922, to August, 1925, was office engineer for Simms Oil Company—Since has occupied his present position with Lone Star Gas Company.

Because it was necessary to sink the two caissons on the north through 50 ft. of quicksand before a clay foundation was reached, a special method had to be adopted. Two cylinders 7 ft. 10 in. in diameter were fashioned of ⅜-in. steel plate welded at the seams. The bottom of each cylinder was fitted with a cutting shoe. The cylinder was lined with concrete. The 24-ft. section, which was sunk first, was placed in position and to the top of it was secured an air lock. This air lock was necessary because, as the caisson sank, it was necessary to maintain an internal pressure sufficient to prevent water intrusion. This air pressure, which reached a maximum of 25 lb. per sq. in., was supplied by two air compressors, one of which was a standby. To enter the working chamber it was necessary first to enter a small cylindrical chamber. In the bottom of the latter was a door leading to the working chamber. As air pressure was maintained constantly within the working chamber this door re-

mained closed until the pressure in the two chambers was equalized by increasing the pressure in the smaller cylindrical chamber, whereupon the door was opened to permit the entrance or exit of workmen. When the workmen had entered the work chamber the door was closed and the pressure was relieved from the upper chamber. It was necessary to have a lock tender on duty at all times as the men in the working chamber could not leave except by his aid.

Equipment employed to remove the sand and gravel consisted of a 6-stage centrifugal pump set at the river's edge. This pump had a capacity of 500 gal. per min. at a pressure of 200 lb. and was driven by a 120-hp. gasoline engine. From the pump a 3-in. line led into the working chamber and connected to a hydraulic excavator. From the latter extended a flexible hose equipped with nozzle, which picked-up the sand and gravel by suction and discharged to the outside through a 4-in. line. The hydraulic excavator was designed to remove 70 percent solids and when solids in greater proportion than this were encountered a 2-in. jet line equipped with a $\frac{5}{8}$-in. nozzle was used to loosen the material.

When the 24-ft. cylinder had been sunk its total depth the 26-ft. cylinder was welded onto it, the air lock secured to the top of the second cylinder, and the excavation continued until a clay foundation was reached, whereupon the bottom was sealed with 2 ft. of concrete. Subsequently, the entire cylinder was filled with reinforced concrete.

The main anchors consist of 14-ft. by 16-ft. concrete blocks extending 2 ft. above the surface of the ground and 7 ft. into the ground. On the south side of the river nine steel piles were driven into the ground to support the anchor, but on the north this procedure was impossible because of the quicksand and an entirely different method was followed. Interlocking steel sheeting $\frac{3}{8}$ in. thick was made into a rectangular box 30 ft. deep, which was sunk to the extent of its entire depth. Sand and gravel were excavated to a depth of 9 ft. and this space was filled with concrete. In each anchor were embedded four U-bolts to which were fastened the two main cables and the two wind cables. To reduce corrosion the U-bolts were inserted in that part of the anchor extending aboveground. The usual practice has been to bury the anchor and the U-bolts.

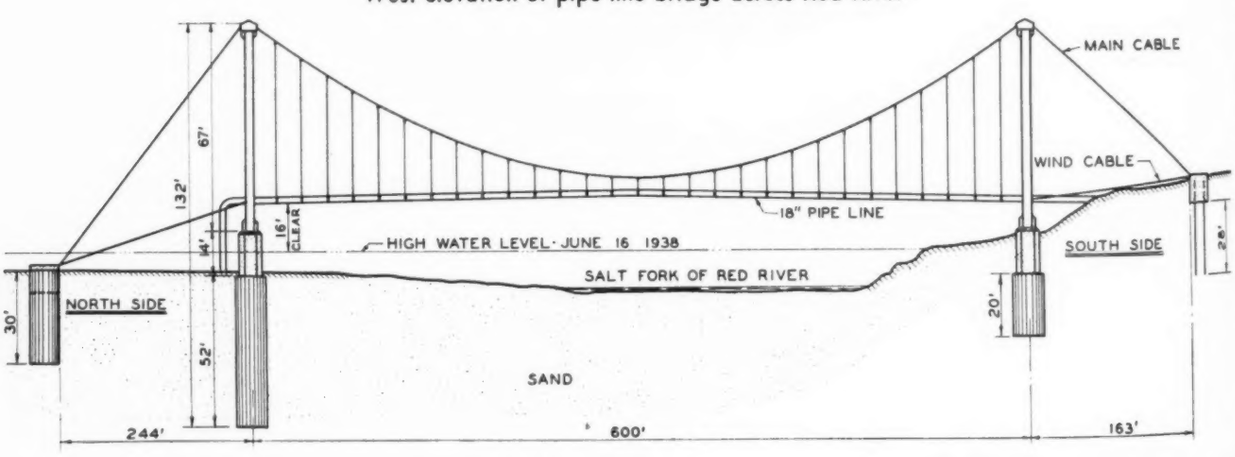
Raising pipe to welding platform

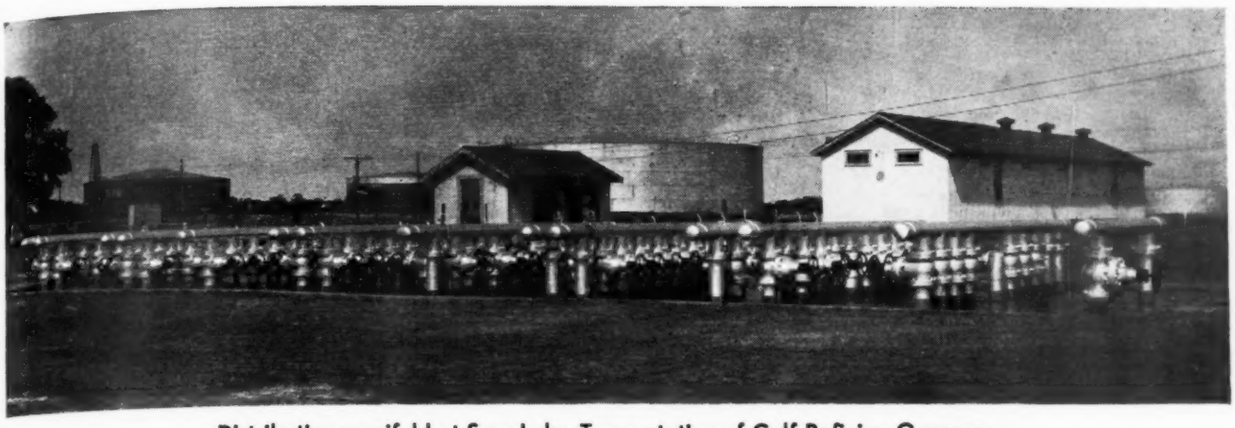
The main suspension cables are of $1\frac{5}{8}$-in. galvanized material having a minimum ultimate strength of 212,000 lb. each, and at each end is a drop-forged steel bridge socket by means of which the cable is fastened to the anchors. The two wind cables are $1\frac{1}{8}$ in. in diameter and have a minimum ultimate strength of 107,600 lb. each. The suspender cables are spaced 20 ft. apart and are fastened at one end to the main cable by $\frac{5}{8}$-in. galvanized turnbuckles, the other end being fastened to the steel cradles that support the pipe line. The wind cables also are fastened to these cradles. Cantilever wind trusses extend 36 ft. from the center of the towers.

When the bridge was completed the next step was the placing of the 18-in. pipe in position. This required but two and one-half days exclusive of the "rigging-up" time, i.e., the time required for building scaffold and placing the blocks, guy lines, gin poles, etc. On the north side of the river the pipe line rises 25 ft. above the level of the ground and this necessitated the building of a scaffold, to the platform of which the 40-ft. lengths of pipe were hoisted by means of a dragline crane and a 35-ft. boom. The scaffold was situated directly in front of the tower and on its platform the pipe joints were electric-welded, three beads and a chill band, or backing-up ring, being used. By a winch and blocks and a cable attached to the shore end, the pipe was moved onto the cradles as the joints were welded. It was necessary that workmen "ride" the pipe to guide it into place and prevent it from snagging. One half the total pipe line, or 300 ft., was thus welded and placed from the north shore. It was not necessary to construct a scaffold on the south shore, as the level of the pipe line was but 15 ft. above the surface of the ground and a hill approximately 60 ft. to the rear of the tower offered an excellent position from which to work.

When the bridge was completed and the 18-in. pipe placed, the camber on the pipe was adjusted for 2 ft. at a temperature of 60° F.

West elevation of pipe line bridge across Red River





Distribution manifold at Sour Lake, Texas, station of Gulf Refining Company

Problems of Oil Dispatching

Seemingly gigantic task of routing millions of barrels of oil annually through a maze of pipe lines becomes routine work except for special details

By W. L. SLOAN
Chief Oil Dispatcher, Gulf Refining Company, Houston Pipe Line Division

APPROXIMATELY 90 percent of the crude oil produced is transported from field to refinery through underground pipe lines. The other 10 percent is moved by tankship, tank car, barge, or tank truck. Thousands of miles of pipe lines, ranging in diameter from 6 in. to 16 in., have been laid throughout the length and breadth of the country so that crude oil may be quickly and efficiently moved from the point of production to refining centers. To the uninitiated the routing of millions of barrels of oil annually through this maze of arteries may seem a gigantic task. In one sense this is true; on the other hand to him whose daily task it constitutes—the oil dispatcher—it has become more or less a matter of routine. To such, then, these words are not addressed, rather to those in kindred lines of the industry who may not be conversant with the problems involved but who may want to become familiar with them.

Suppose we begin with the oil after its arrival at the producer's tanks and follow it to its destination; this should give us a clear idea of the importance of the oil dispatching department of an oil company and the duties of the men who comprise its personnel.

Before the producer turns oil into these tanks, the pipe-line gauger has strapped each tank and from such measurements the tank tables are made, from which can be determined the number of barrels contained in the tank when the surface of the oil is at any given height. Copies of these tables are given the producer, the pipe-line department of the company taking the oil, and the accounting department.

After the producer has filled his initial tank, the gauger for the pipe-line company inspects the oil to determine if it is "pipe-line oil." The oil being of the proper specification, the pipe-line gauger and a representative of the producer together gauge the tank and lock the gate valves between the several tanks to obviate the possibility of pumping oil from a tank other than the one intended.

The oil now enters the gathering system, which usually consists of an 8-in. or 10-in. main line and 2-, 4-, and 6-in. laterals, and is moved to storage tanks at the pipe-line station by gravity, suction, or field pumps, as the case may be. As the oil is being received the gauger at the pipe-line station is in constant communication with the field gauger. He knows at all times what leases are pumping and the number of barrels he should receive each hour. Any discrepancy between the amount pumped by the field stations and the amount received by the main station usually is immediately discernable, but as a safety measure a checkup is made each day at 7 a.m. At the receiving station hourly gauges are taken on the tanks and reports are submitted to the dispatcher at company headquarters so he can follow the movement of the oil and be in position to locate any discrepancy. The dispatcher thus at all times must have at his finger tips, so to speak, a knowledge of the entire pipe-line system. His duties make it imperative that he know the capacity of all pumps, tanks, and lines that are in use at each station, the gravity of the oils being pumped, and the percentage of water and sediment, and he must be able to figure displacements, issue instructions as to which tanks to use and the pressure to be carried, and check the flow of oil through the system.

The writer has found it helpful to have in his office a large chart or map of the company's system on which are spotted all stations and tanks. By using large-headed pins of various colors a visible record of the different grades of oil can be maintained. Only a glance

at the map is required to determine what grade of oil is contained in each tank. If that grade of oil is pumped from the tank and another grade pumped in, the pin is replaced by one of another color.

In the early days of the industry oil dispatching was not so complicated as it is now. There were but two grades of crude, "light" and "heavy". Today there are many grades and they must not be mixed, so the oil must be pumped in blocks. As an example of how this is accomplished let us assume that the trunk line is filled with Panhandle crude for a distance of 500 miles and it is desired to pump West Texas crude. The dispatcher issues an order to the engineer and operator at the No. 1 station to discontinue pumping Panhandle crude and begin pumping West Texas crude as soon as ready and notify headquarters when he has done so. When notified that the movement of West Texas crude has begun the dispatcher will begin figuring the line displacement between the No. 1 and the No. 2 stations. The hourly gauges supplied by the station gauger serve as the basis for these calculations. When the first of the West Texas crude reaches the No. 2 station the dispatcher instructs the operators at that station to turn the stream into an empty tank, specifying the tank. The No. 2 station continues to pump Panhandle crude until sufficient West Texas crude has accumulated in the station's working tanks to begin the displacement. At that time the No. 2 station is given instructions to discontinue pumping Panhandle and begin moving West Texas crude. The dispatcher must now calculate the displacement between No. 2 and No. 3 stations and repeat the procedure between the various stations until the oil reaches its destination. Long before a certain grade of oil has reached its destination, however, other grades usually have been started on their journey, and so it frequently happens that several grades of oil are being pumped through the system simultaneously.

The dispatcher's office, too, serves as a clearing house for the repair of leaks or breaks in the line. A break reveals itself by a drop in station pressure. Upon noticing this pressure drop the engineer in charge shuts-down the pumps and notifies the dispatcher, who, in turn, issues instructions to both the pumping and receiving stations to start the suction pumps. The oil is thus pulled from the break in both directions. Simultaneously instructions are given to send line riders to locate the break.

W. L. SLOAN

was a railroad telegrapher at McLeansboro, Illinois, before entering the oil business. He followed the oil boom at Spindletop the early part of the century, and in 1903 joined the staff of the "Gulf" as a telegrapher at the Sour Lake, Texas, station. The following year he was transferred to the company's Batson station. In 1905 he was moved to the main office, then in Beaumont, and made chief oil dispatcher, the position he has held since.

It is the duty of the engineer in charge of the pumping station first to examine manifold gate valves, pressure gauge line, and the strainer box to determine if the trouble is at the station. Sometimes it is. Frequently a drop in pressure results from an obstruction in the strainer, which is in the suction line between the station and the manifold. If the trouble is not found at the station, the line riders are sent out, and when the break is found its location is reported by telephone. Most pipe lines are paralleled by a telephone line and the line riders are equipped with telephone test sets. Breaks usually are in the form of a split joint or a parted line. After repairs have been made it is necessary to re-gauge the tanks at the pumping and receiving stations, and the amount of oil taken from the line by the suction pump is reported to the dispatcher so that he will know approximately the volume required to refill the line.

Small leaks that result from rust holes do not affect station pressure but reveal themselves in another manner. A shortage that otherwise cannot be accounted for is attributed by the dispatcher to a leak and line riders are instructed to cover the system. Usually the leak when found can be repaired temporarily by a pipe-line clamp or saddle and the line returned to full efficiency until a permanent repair can be made.

The leak temporarily repaired, the construction foreman makes an inspection to determine what the next step shall be. Should he decide a section of pipe must be replaced, the dispatcher, after conferring with the division superintendent, consults his profile map to ascertain the contour of the country where the replacement is to be made. If the leak is at the top of a hill suction pumps can be put into operation at the pumping and receiving stations, drawing the oil away from the break, which then can be repaired without loss of oil. More often, however, the break will be found to have occurred at a low point in the line and it will be necessary to spot a water plug. The task of determining the amount of water required falls to the dispatcher and it is his duty, also, to issue the subsequent orders. At his instructions the pumping station is shut-down and a line scraper inserted. The pumps are then started, pumping water through the line behind the line scraper. When sufficient water has been pumped, the station is again shut-down for the insertion of another line scraper, whereupon the pumps are started and continue pumping until the water plug is spotted. The station is then shut-down and the construction foreman and his crew can proceed to make the repair.

The repair made and pumping resumed, the line riders follow the scrapers into the receiving station, where samples of the oil are examined to determine if any water-oil mixture remains in the line, in which event it is turned into a separate tank, the water settled and drawn-off, and the oil returned to the working tank.

While the dispatcher is thus keeping constantly in contact with the movement of oil through the system, he must also at all times be in close touch with the various refineries to know their requirements and see that they are filled.

The dispatcher's office is never closed, the wires never silent for long. One shift of telegraphers succeeds another, but the "job" goes on 24 hours a day and seven days each week. The flow of oil is continuous and in the key city, or headquarters, the dispatcher must always be on duty checking and switching, directing the flow of oil into the proper channels, for he is the man responsible for its safe journey from the point of origin to the numerous refineries that make it into fuel for consumption throughout the world.

Measurement of Load on Cable During Cable-Tool Drilling

Kemler Well Weigher is suitable instrument for indicating satisfactory hitch and number of strokes per minute

By
G. S. PETERSON

Engineer, Gulf Research and Development Company, Pittsburgh, Pennsylvania

G. S. Peterson received an A.B. degree from the University of Nebraska in 1923 and a B.S. degree in engineering from the University of Illinois in 1927. From 1927 to 1931 he was an engineer on the staff of the Westinghouse Electric and Manufacturing Company and in 1931-32 occupied a similar position with the Union Switch and Signal Company. Since 1933 he has been an engineer on the staff of the Gulf Research and Development Company at Pittsburgh, Pennsylvania.

VALUABLE data on polished-rod loads of pumping wells have been obtained by production companies and oil-well equipment manufacturers. In the literature, however, there is little if any evidence of accurate data having been recorded on cable loads during cable-tool drilling. One of the principal reasons is the fact that very few of the strain gauges and weight indicators now in use for measuring static and polished-rod loads are suitable for accurately indicating and recording the sudden changes in the cable load during the drilling motion.

It is the purpose of this article to describe briefly the weighing of cable loads by a Kemler Well Weigher during the drilling of a well near Washington, Pennsylvania, and to discuss the nature of the data obtained. No attempt will be made to describe the well weigher in detail as this has been done previously[1]. The instrument consists primarily of a magnetic strain gauge and photographic recording equipment. The strain gauge is shown in Fig. 1 mounted between the cable hitch and the temper screw in such a way as to support the total cable load in compression. No special equipment is required to mount the strain gauge in this manner other than the links and rod as indicated in Fig. 1.

Before discussing the results obtained from weighing the cable loads under different drilling conditions, it

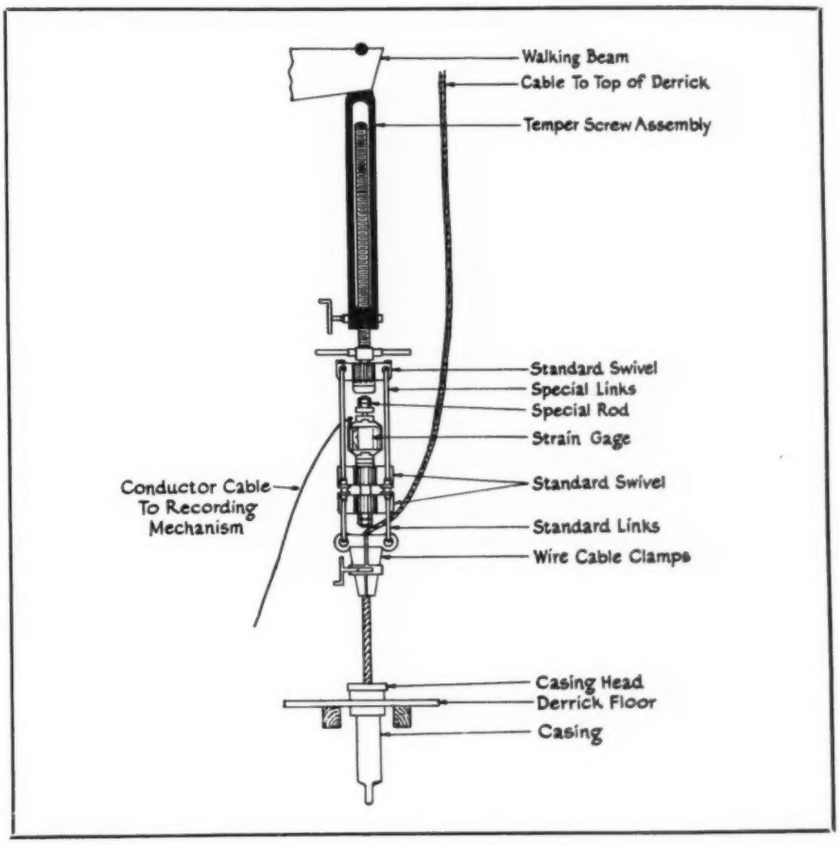


Fig. 1. Method of installing strain gauge in cable-tool drilling line

[1]Transactions A.I.M.E., Vol. 114 (1935).

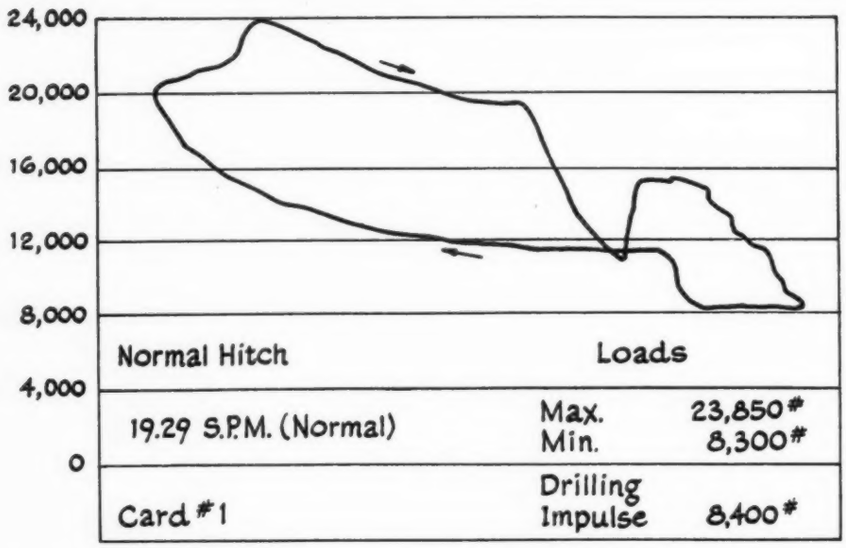


Fig. 2

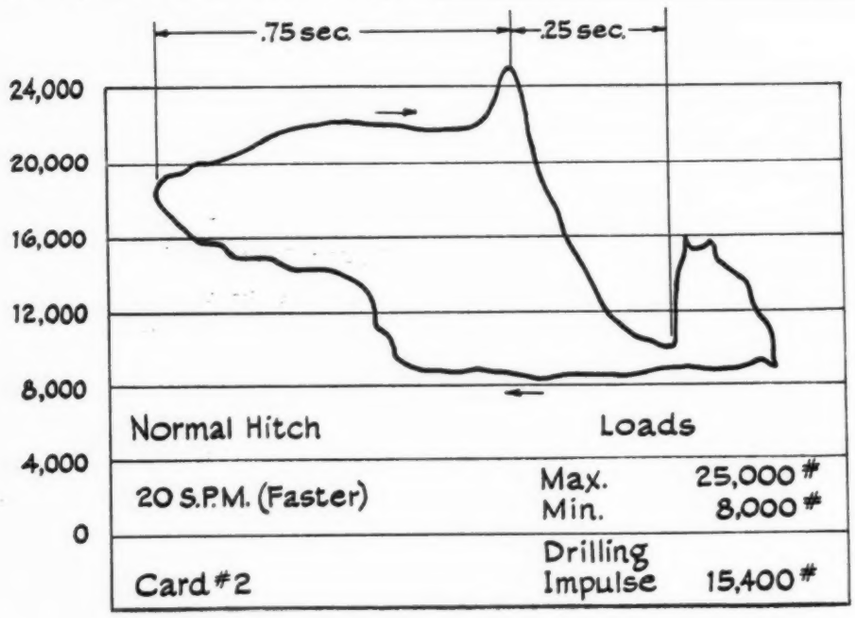
the operating conditions necessary for the most efficient drilling.

Stress-versus-stroke diagrams were taken on the well at three different drilling speeds with normal hitch and a loose hitch. The speeds are referred to in the figures as normal, faster, and slower. Normal speed and hitch as used in this connection refer to the speed and hitch regarded as the most satisfactory for drilling by the driller on the job at the time of weighing the well.

should be pointed out that in cable-tool drilling the present practice is for the driller to determine the best drilling speed and hitch on the basis of judgment supported by experience. Although this method has proved to be satisfactory, as is evidenced by the results obtained, it is of interest to study the variation of cable loads with small changes in drilling speed and hitch. This information is not only of definite value in determining the best operating speed and hitch from the standpoint of duty on drilling equipment, but can be used as a basis for studying the drilling motion. An intelligent study of the effect of operating conditions on the drilling motion together with a study of the most effective drilling motion as revealed by the drilling rate should provide a basis for determining

TABLE I
Well Data

Depth (at time of weighing)		6722 ft.
Cable, total length		6672 ft.
lower section—4000 ft. of 1-in. H.C.		6400 lb.
upper section—2672 ft. of 1-in. I.W.C.		4270 lb.
Modulus of 1-in. H.C.		13×10^6
Modulus of 1-in. I.W.C.		16×10^6
Weight of 1-in. H.C.		1.6 lb. per ft.
Weight of 1-in. I.W.C.		1.73 lb. per ft.
Net area of 1-in. H.C.		0.407 sq. in.
Net area of 1-in. I.W.C.		0.470 sq. in.
Jars, Weight	(approx.)	500 lb.
Length		6 ft.
Travel		12 in.
Drill stem, Length		40 ft.
Diameter		4¼ in.
Weight	(approx.)	2000 lb.
Bit	(approx.)	500 lb.
Walking beam stroke		32 in.
Normal hitch, walking beam in down position tools 8 ft. above formation (static)		8 ft.
Normal drilling speed		20.29 s.p.m.



Data Taken

Typical cards taken under the conditions outlined are shown in Figs. 2-7. A study of the card diagrams shows, in general, the change in magnitude of the maximum and minimum cable loads together with change in load resulting from the tool striking the formation. This change is of particular interest in a study of the drilling motion. This change in load is referred to as the drilling impulse.

By comparing the magnitude of the drilling impulse in Fig. 2 with that

Fig. 3

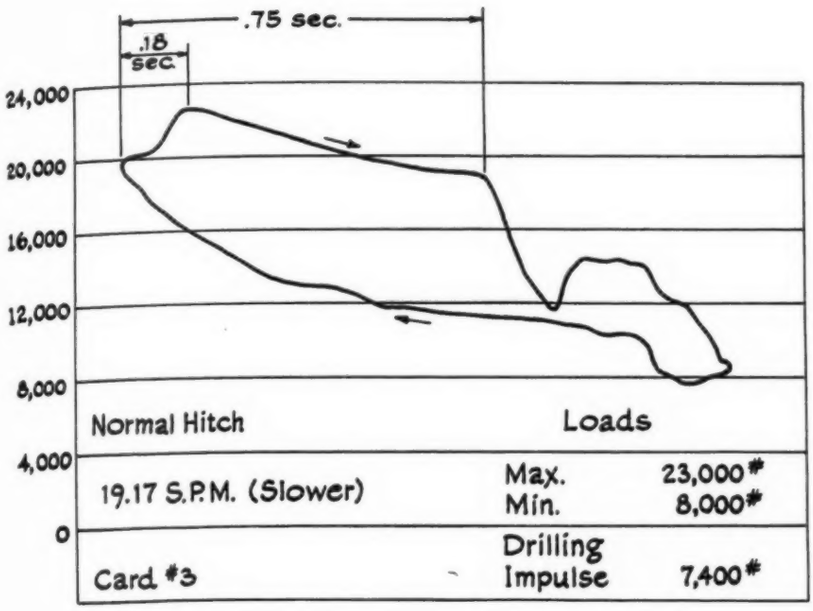


Fig. 4

shown in Fig. 3 it will be seen that the value changes from 8400 lb. to 15,400 lb. or nearly 100 percent for a change in speed from 19.29 s.p.m. to 20 s.p.m. A similar comparison of the corresponding values in Fig. 2 and Fig. 4 shows a change from 8400 lb. to 7400 lb. for a decrease in speed from 19.29 s.p.m. to 19.17 s.p.m.

A study of the conditions shows that the large increase in drilling impulse when the speed is increased above normal was no doubt the result of a change in speed that established a closer agreement between the drilling speed and the natural frequency of the cable and tools. This conclusion is substantiated to a great extent by the calculation given below on the determination of the natural frequency of the cable and tools. The values used in the calculation are given in Table 1.

$$*T = 2\pi\sqrt{\frac{S_{st}}{q}}$$

Where $S_{st} = \dfrac{W + 1/3\ qL}{K}$

W = Weight

K = Spring constant

q = Weight of cable per unit length

L = Length of cable

g = Gravity

$$K = \frac{14000000 \times 0.42}{6672 \times 12}$$

= 73.4 lb. per in. elongation

$$S_{st} = \frac{3000 + 3224}{73.4} = 84.8 \text{ in.}$$

$$T = 2\pi\sqrt{\frac{84.8}{386}} = 2.95 \text{ sec.}$$

$$F = \frac{60}{T} = \frac{60}{2.95} \text{ or } 20.3 \text{ s.p.m.}$$

It should be noted that the above calculation does not give an exact solution as pointed out in the reference but does give an approximate solution when the ratio of the mass of the cable to that of the tools is not too great.

*Timoshenko and Lessels, "Applied Elasticity," pp. 314, 316-317.

It is well known that the life of the sucker rods and associated equipment in some pumping wells operated at some speeds is short compared to that at other speeds. Upon analysis it was found that in certain wells the pumping speed conformed closely with the natural frequency or some multiple of the natural frequency of the rod string and pump.

In cable-tool drilling the most desirable speed is one that approximates the natural frequency of the cable and tools or some simple multiple or fraction of the natural frequency, such as one-third, one-half, or two. At these speeds the amplitude of the tool movement can be several times that of the walking-beam stroke, assuming the hitch is suitable and the stroke motion is approximately simple harmonic motion. Large movement of the tools should cause a greater impact between the tool and formation, correspondingly increasing the rate of drilling. In the well on which the cards shown were taken, the hitch was so made that the tools were approximately 8 ft. above the formation. This means that the tools must have traveled at least 8 ft. above the static position, a minimum total travel of 16 ft. This assumes that the tools were in phase with the walking beam, which is very improbable, so that the total amplitude of

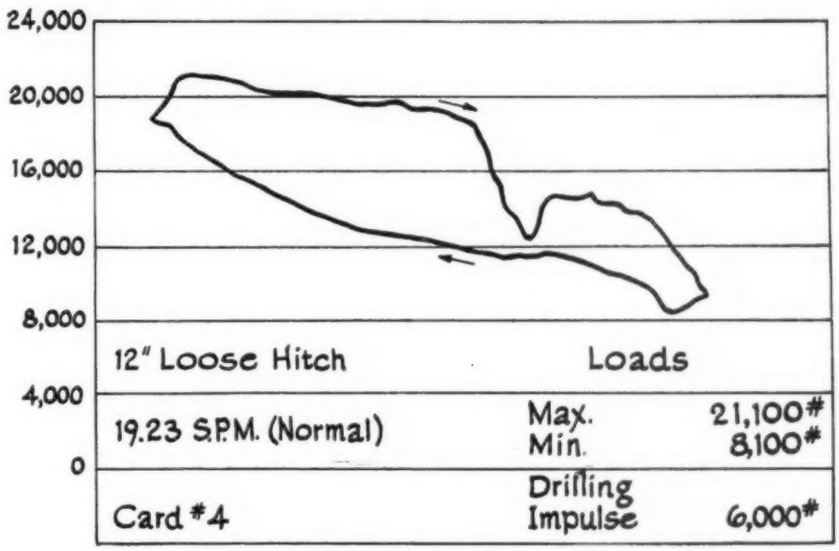
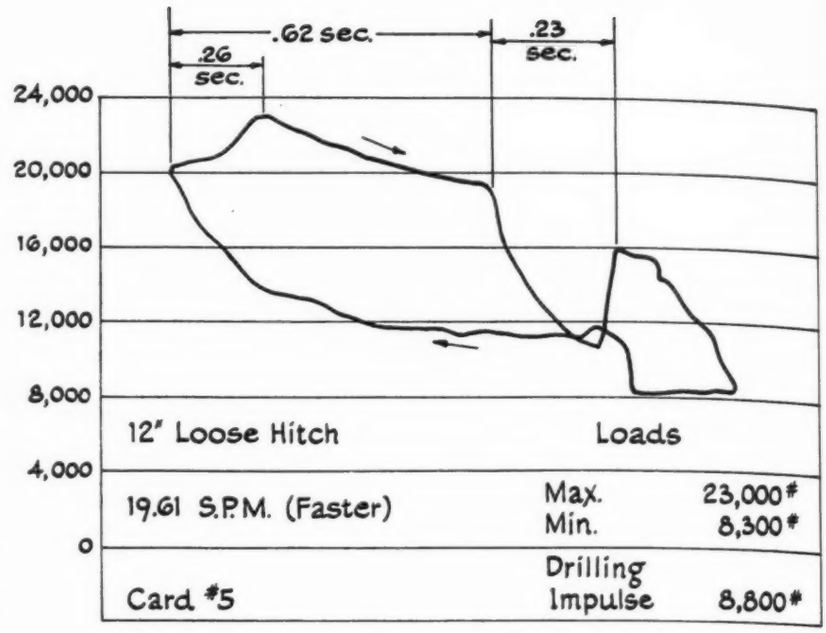


Fig. 5

Fig. 6



the tool travel exceeded 16 ft. for a walking beam stroke of 32 in. or a ratio of travel greater than six to one.

A comparison of the cards shown in Figs. 2, 3, and 4 and those in Figs. 5, 6, and 7, respectively, shows in general the effect of a change in hitch. The speeds are very nearly the same in Figs. 2 and 5 so that the difference between the drilling impulse of 8400 lb. and 6000 lb. as shown is primarily the result of a change in hitch of 1 ft.

A detailed study of the cards in light of the theory involved reveals valuable data on the mechanics of cable-tool drilling. For example, the time phase relationship between the tools and the walking beam can be determined accurately by considering the time required for the impulse to travel the length of the cable. By subtracting this interval from the time shown in the cards from the beginning of the up-stroke to the start of the drilling impulse, the phase difference between the tools and walking beam can be obtained in terms of time. The time intervals between different points on the diagram were determined from a timing wave recorded on the original card. The timing wave was recorded simultaneously with stroke motion by means of a timing device of the vibrating-reed type built into the recording mechanism.

To obtain a true picture of the variation in cable load with respect to magnitude and time phase relationship, an instrument without damping or lag effects must be used, as the variations in cable load during the stroke motion correspond to rather high frequencies. In addition the strain element or part of the instrument subjected to the cable load must be very rugged in order to withstand the impacts imposed by the drilling impulse.

The principal disadvantage of a strain gauge of the mechanical type for this service is the fragility of the recording mechanism. This characteristic is inherent in the mechanical type of instrument, because the recording parts must be light in order to be sensitive and at the same time they must be mounted directly on the strain gauge, which is subjected to the impact loads.

The disadvantages in using an instrument of the hydraulic type for measuring sudden changes in load are the cushion effect on the peak loads together with the damping and lag in the recording mechanism. The introduction of a bellows element between the walking beam and the cable results in a shock-absorber effect on the loads, and therefore a reduction in magnitude. The compressibility of the liquid column together with the expansion of the connecting tubing and the inertia of the recording pressure gauge result in damping and lag effects in the recording mechanism, which add to the shock-absorber effect introduced by the strain element.

The Kemler Well Weigher is particularly suitable for weighing loads of the type encountered in cable-tool drilling, because of its sensitivity and ruggedness. The combination of a magnetic strain gauge and photographic recording mechanism eliminates virtually all damping and lag effects, as there are no moving parts except the oscillograph element. The only part of the instrument connected to the cable is the strain gauge itself, which is very rugged. The recording mechanism is a separate part of the instrument and can therefore be placed at some point remote from the moving parts of the drilling rig.

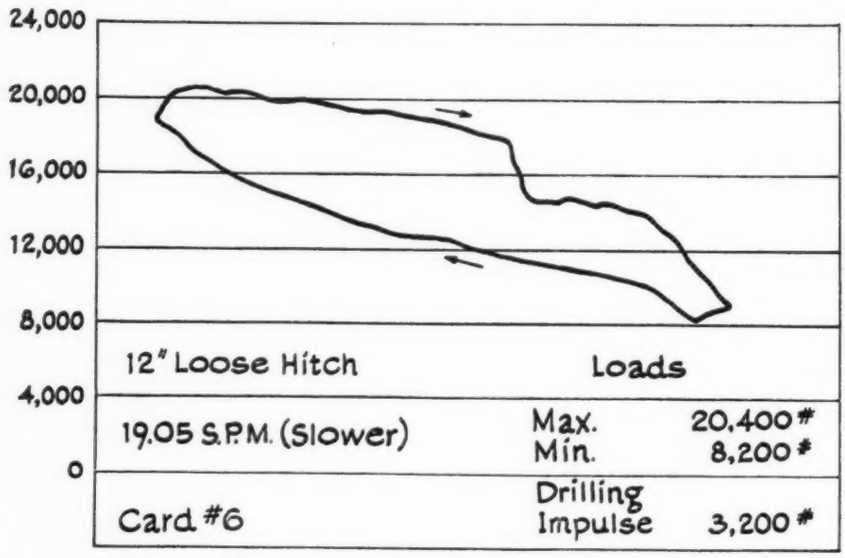


Fig. 7

P 225.1
P 729.

Determination of Salts in Crude Oil

Part 2

METHODS OF EXTRACTION OF SALTS FROM THE OIL

By C. H. M. ROBERTS, Director of Research

and

R. W. STENZEL, Research Staff, Long Beach Laboratory
Petroleum Rectifying Company of California, Los Angeles

IN Part I[14], the general problem of the determination of salts in crude oils was considered in some detail and the methods employed in the various analytical procedures were critically discussed.

It is now proposed to present the results of tests of various representative methods and to describe in detail those methods that, in our opinion, are most suitable for general use. The general form of discussion, as regards division of subjects, will follow that employed in the previous article.

Samples and Sampling

Before proceeding with the detailed discussion of extraction and analysis of salt-containing oils, we present some observations made in the course of this work, which indicate forcibly the kinds of changes that may occur in heterogeneous systems of the sort under discussion.

A sealed sample of salt-containing oil from the West Branch field, Michigan, was shipped to Petreco's Long Beach, California, laboratory. Its properties, as reported from the field, are given in the first line of Table 2. Upon receipt at the laboratory, the sample was thoroughly mixed and an average sample tested for gravity, cut, and salt content. The results of this test are shown in the second line of the table. It is seen that the sample differs only in B. S. & W. content from that reported from the field, this difference being due to differences in methods of determining cuts. The field sample was diluted 50/50 with benzol, whereas in the laboratory the carbon disulphide-gasoline mixture used for waxy oils was employed. The latter mixture gives lower cuts because better separation is obtained. After one month in the laboratory, during which time the sample was frequently mixed and opened for withdrawal of test samples, its properties had changed to those shown in the third line of the table. It should be noted that these changes occurred despite the exercise of usual precautions to prevent evaporation losses. The abnormally low salt content of the third sample was probably due to separation of salt crystals in the form of a scum, which adhered tenaciously to the container. As shown in line four, the chloride content of the oil calculated from analysis of West Branch brine was almost exactly that found in the sample as received. This was consistent with the observation that this oil, as handled in the field and as received at the laboratory, contained only emulsified water particles, having the salinity of normal field brine. After one month of use and exposure, continued evaporation of water had caused formation of swarms of chloride crystals in the oil. As an interesting commentary on these changes, it may be noted that emulsions formed during the extraction procedures were resolved much more readily on the sample containing salt crystals than on a similar sample containing brine particles only.

Biographical sketches and photographs of the authors will be found on page 35 of the January issue of *The Petroleum Engineer*, in connection with Part 1 of this series.

Microscopic Examination

As a preliminary step in examination of a crude oil, a microscopic examination of the oil is often informative, and has been routine in this laboratory for many years. By this means, the presence and sometimes the nature of solid materials in the oil can be determined. In the hands of a skilled operator, the microscope can be made a useful adjunct to the examination and analysis of crude oil for salts[5†]. It cannot, however, be substituted for quantitative analytical determinations, so that its use is limited. It is often desirable to make photomicrographs of the oils in order to have a permanent record, but such records have little value unless they are accompanied by an interpretive discussion based upon direct examination and manipulation of the sample photographed. Only in this way can clear distinctions be made between waxes, resins, and other dispersed solid organic matter and randomly shaped particles of dirt, sand, iron rust, carbon, silica, volcanic ash, and the like. Similarly the presence, crystal habit, and sometimes the identity of dispersed crystalline inorganic matter may be determined. In oils that have been exposed, such as the West Branch sample previously discussed, the presence of salt crystals in water drops and as discrete particles in the oil is easily demonstrated. A typical photomicrograph of such a sample is shown in

†Numbers refer to articles listed in the bibliography at the end of this installment.

TABLE 2

Change in Properties of Oil

Lab. sample D-753, West Branch, Michigan

	Date	Gravity °A.P.I. at 60° F.	B.S. & W., percent	Total chlorides, p.t.b.*	Microscopic examination
1.	11-10-37	33.0	0.7-0.9	272-327	.....
2.	12- 1-37	approx. 32.9	0.4	275	All water-in-oil emulsion. No salt crystals.
3.	1- 4-38	.....	0.15	187	Some water-in-oil emulsion. Many salt crystals.
4.	Calculated salt from brine analysis		0.4	277	.....

*p.t.b. = lb. NaCl per 1000 bbl. (42 gal.) of oil.

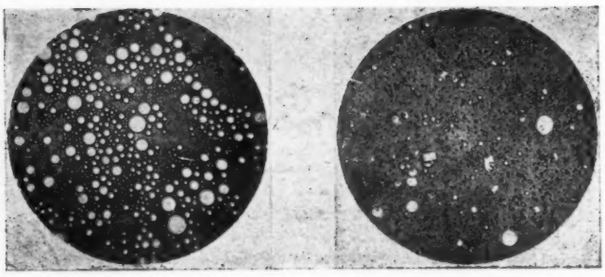


Fig. 2a

Fig. 2b

Fig. 2b, together with a companion photomicrograph of the original oil, Fig. 2a, containing emulsion particles only.

Methods for Extraction of Salts from the Oil

The Petroleum Rectifying Company of California for a considerable time has used several methods for salt extraction that were developed in our laboratories and have given entirely satisfactory results. The object of the present investigation was to learn whether other solvents and operating conditions would provide a simpler or more generally applicable procedure.

In the development of suitable methods for the analytical extraction of salts from crude oils, the factors that appeared to require special investigation were:

a. Use of oil-soluble diluents and mutually soluble solvents.
b. Use of demulsifying chemicals.
c. Conditions of mixing of oil and water.

For reasons discussed in Part I of this paper[14], the only extraction methods that have been seriously considered as suitable for general use are those in which the centrifuge is employed for separation of the aqueous extract. The justification of this view rests upon a background of considerable experience and will be demonstrated by tabulated results of gravity versus centrifugal separation experiments. In comparing the effectiveness of diluents, mutual solvents, demulsifying chemicals, etc., centrifugal separation was used throughout, in order to accelerate the separations and to permit quantitative comparison of results.

a. Use of Oil-Soluble Diluents and Mutually Soluble Solvents

The equipment used in investigating the effect of various solvents and diluents was the piston emulsifier shown as Fig. 1 in Part I of this paper. The mixture employed was as follows: 50 ml. of crude oil, 75 ml. of the solvents shown in Table 3, and 75 ml. of water. These components were mixed and heated to 175 or 185° F. in a water bath, were tightly emulsified by 15 strokes of a tight-fitting piston, transferred to centrifuge tubes, and centrifuged for 10 min. at 1800 r.p.m. (radius of swing of centrifuge 11 in.). The two crude oils employed were chosen to represent extreme types, West Branch, Michigan, oil being a high-gravity, low-viscosity, waxy oil, whereas Huntington Beach, California, oil is a low-gravity, high-viscosity, asphaltic oil. Xylol was chosen in preference to benzol principally because of its higher boiling point (see also Part I of this paper[14]).

Results of these experiments are shown in Table 3, from which it can be seen that, in general, quite different degrees of stability are exhibited by emulsions in the two oils tested. The use of exclusively oil-soluble diluents leads to formation of emulsions of greater stability than those formed when mutually soluble solvents are also present. Even in the latter case, however, the effects of such solvents are highly specific, as indicated by results of the last three combinations given in the table. It therefore appeared highly desirable, if not absolutely necessary, to modify the procedure in order to provide for positive resolution of the residual emulsion.

b. Use of Demulsifying Chemicals

In applying demulsifying chemicals to aid in resolving emulsion in salt extraction systems, care must be exercised to see that the compounds chosen do not affect the analytical results. As previously discussed, compounds that affect the pH or total acidity of the system, or that may react with alkaline earth compounds in the brine, should not be used. Among the most readily available compounds suitable for the purpose are materials produced by the Tretolite Company, of which the following were chosen for test: R-1, R-2, N-13, J-28, L-10396, all of which are commercially available. In the following tests, the effort was made to avoid the use of mutually soluble solvents by substitution of a suitable Tretolite. That this was unsuccessful is shown by the results of tests 1-5 inclusive, in Table 4. Further tests were then made, employing the best solvent-diluent combination previously developed and L-10396, which had proved to be the chemical best suited to our needs.

TABLE 3

Effect of Diluents and Mutual Solvents on Emulsion Stability

		Oils	
	Sample no.	D-753-4	D-789
	Field	West Branch,	Hunt. Beach,
	State	Mich.	Calif.
	Gravity, °A.P.I.	33.5	19.6
	Cut, percent	0.15	0.9
	Chloride content, p.t.b.	185	95
Expt. no.	*Solvents (total vol. 75 ml.)*	*Residual emulsion, percent*	
1.	Xylol 75 ml.	37.5	49.5
2.	Chlorex 75 ml.	79.0	-----
3.	Carbon tetrachloride 75 ml.	39.0	-----
4.	Xylol 60-67.5 ml.—CS_2 15-7.5 ml.	18.0	42.5
5.	Xylol 60-67.5 ml.—CCl_4 15-7.5 ml.	18.5	49.5
6.	Xylol 67.5 ml.—den. alcohol 7.5 ml.	0.2	-----
7.	Xylol 50 ml.—acetone 25 ml.	-----	0
8.	Benzol 50 ml.—acetone 25 ml.	0.5	-----
9.	Xylol 67.5 ml.—acetone 7.5 ml.	0.2	22.5
10.	Xylol 67.5 ml.—n-amyl alcohol 7.5 ml.	40.0	0
11.	Xylol 67.5 ml.—sec-butyl alcohol 7.5 ml.	17.5	0
12.	Xylol 60 ml.—acetone 7.5 ml.—sec-butyl alcohol 7.5 ml.	9.0	0

In these experiments the oils used were the same as in the previous work. The procedure was to emulsify a mixture of 50 ml. oil, 75 ml. distilled water, and 75 ml. solvents, which had been heated to approximately 180° F. Emulsification was accomplished in the piston emulsifier, using 30 strokes of a tight-fitting piston. The emulsion was then transferred to centrifuge tubes, one drop of a 10 percent xylol solution of Tretolite being added to each tube. The tubes were then rather vigorously shaken to mix the chemical and allow time for resolution of the emulsion. They were then centrifuged for ten min. at 1800 r.p.m. Results of these experiments are shown in Table 4, results being stated as percentage emulsion not resolved. From these results, the superior effects of the mixture of L-10396 with mutual solvents are apparent.

At a somewhat later stage in the work, an additional limitation of demulsifying agents was encountered in connection with determination of chlorides in the aqueous extract. This difficulty arose when using Tretolite B-489, a type of compound that formerly had been used in salt extraction analyses. In presence of alkaline brines containing low concentrations of alkaline earth salts, B-489 caused interference in determination of chlorides by the Mohr method. This behavior of the B-489 type of compound indicated the necessity for using one that is substantially insoluble in, as well as nonreactive with, brines, and this and previously stated requirements were met by use of the compounds listed in Table 4.

c. Conditions of Mixing of Oil and Water

In the course of a varied program of tests designed to develop the most favorable conditions for salt extraction, a number of apparently secondary factors were found to affect materially the ease or degree of extraction and separation. For example, as between emulsifying the mixture of oil, water, and solvents at room temperature and then heating to 180°, compared to heating the mixture before emulsification, the latter procedure produced uniformly better results. In addition, quicker and cleaner centrifugal separation is produced when the emulsified mixture is given an additional heating after emulsification and before centrifuging. The experiments upon which these conclusions were based were necessarily more or less qualitative, but the indications from a number of tests on various types of oils were unmistakable.

TABLE 4

Effect of Solvents, Diluents, and Demulsifying Chemicals on Emulsion Stability

	Oils		
Sample no.	D-753-4		D-789
Field	West Branch,		Hunt. Beach,
State	Mich.		Calif.
Expt. no. *Solvents*	*Tretolite*	*Residual emulsion, percent*	
1. Xylol 75 ml.	R-1	8.0	-----
2. Xylol 75 ml.	R-2	16.0	-----
3. Xylol 75 ml.	N-13	21.5	47.5
4. Xylol 75 ml.	J-28	9.5	-----
5. Xylol 75 ml.	L-10396	trace	37.0
6. Xylol 67.5—sec-butyl alcohol 7.5	L-10396	0	-----
7. Xylol 70 —sec-butyl alcohol 5.0	L-10396	0	0
8. Xylol 70 —amylic alcohol 5.0	L-10396	0	5
9. Xylol 70 —n-amyl alcohol 5.0	L-10396	4.5	-----

The conditions and degree of mixing and agitation suitable for maximum salt extraction were the subject of numerous experiments. Although, from previous experience, it was felt that the most satisfactory extraction methods are those employing the piston emulsifier for mixing the components of the system, parallel experiments were made using separatory funnel shaking, all separations being made centrifugally. In judging results of various extraction procedures, chloride determinations were made on the aqueous extracts. The numerical values in Table 5 are pounds of NaCl per 1000 bbl. of oil (p.t.b). The same mixture of oil and solvents was used in all tests, the variable being the kind and duration of agitation.

As a result of the extensive experimental work performed on extraction methods, of which the tabulated results already given are merely typical examples, the following procedure was adopted as being satisfactory for all types of oil tested to date:

Experimental Extraction Procedure

1. Mix 50 ml. oil, 75 ml. distilled water, 70 ml. xylol, 5 ml. sec-butyl alcohol, and 2 drops of a 10 percent xylol solution of Tretolite L-10396. Note: Only the oil sample requires accurate measurement, preferably by pipette.
2. Heat mixture five min. at 180° F., in a piston emulsifier cylinder. (See Fig. 1, Part I of this paper.)
3. Emulsify with 30 strokes of a tightly fitting piston and transfer to centrifuge tubes.
4. Rinse emulsifier with 5 to 10 ml. xylol and add to tubes.
5. Heat tubes five min. at 180°F.
6. Centrifuge ten min. at 1800 r.p.m. (11-in. radius of swing).

TABLE 5

Effect of Degree of Emulsification on Salt Removal

A. West Branch oil—Sample No. D-753-4—NaCl 185 p.t.b.

Expt. no.	*Equipment*	*Agitation*	*Salt extracted, p.t.b.*
1.	Piston emulsifier	5 min.—very loose piston	164
2.	Piston emulsifier	15 strokes—tight piston	180
3.	Piston emulsifier	30 strokes—tight piston	185
4.	Separatory funnel	7 min. shaking	155
5.	Separatory funnel	7 min. shaking	158

B. Huntington Beach oil—Sample No. D-789—NaCl 95 p.t.b.

Expt. no.	*Equipment*	*Agitation*	*Salt extracted, p.t.b.*
6.	Piston emulsifier	30 strokes—tight piston	94.4
7.	Separatory funnel	6 min. shaking	84.5

7. Siphon aqueous layer. Recentrifuge and record volume of residual B. S. & W. in tubes, correcting the titration value for this residue.

This method has proved satisfactory in extracting and separating emulsions of oils of the types shown in Table 6, which constitute a sufficiently wide variety to lend confidence that the method can be applied to oils of all types likely to be encountered in salt analysis.

TABLE 6

Oils Used in Development Tests

Lab. no.	*Field and state*	*Gravity, °A.P.I. at 60° F.*	*Total cut, percent*	*NaCl, p.t.b.*
D-753-4	West Branch, Michigan	33.5	0.15	185
D-789	Huntington Beach, California	19.6	0.9	95
D-726	New Mexico—refinery sample	32.6	0.1	.....
D-254	West Texas	26.2	0.1	.....
B-60	Oklahoma City, Oklahoma	36.0	3.2	.....
D-428	Kansas—refinery sample	38.4	1.6	154
D-795	Signal Hill, California	25.9	0.9	.....
D-722	South Mountain, California	23.0	0.4	142
B-397	Goose Creek, Texas	22.0	0.2	.....

In order to judge the efficiency of the experimental extraction procedure, a synthetic salty oil was prepared. Signal Hill oil No. D-795 was used, being repeatedly desalted until it gave a negligible test of chlorides. The oil was then tightly emulsified to a 1 percent water content using Signal Hill brine that had been fortified to approximately 6.7 percent NaCl. Natural oil field brine was used in order to assure the presence of whatever interfering substances there might be in natural oil-brine systems. The fortified brine was analyzed for chlorides and the percentage brine employed was such as to give a calculated sodium chloride content in the raw oil of 239 p.t.b. This oil was extracted by a number of methods, with the results shown in Table 7.

In examining the results of the analyses in Table 7, the progressive increase in salt content in the three extractions by the experimental method was noted. These extractions had been made at intervals of about a day, so it was suspected that progressive evaporation of the oil, due to repeated handling, shaking, and sampling, was responsible for the apparent salt increase. Examination of the oil showed that its A.P.I. gravity had decreased from 25.9° to 24.2°, a loss of 1.7° A.P.I., which corresponded to a volumetric loss of approximately 4.3 percent[16]. The salt values, when corrected for concentration due to evaporation of the oil, became approximately 227, 228, and 225; an average of 226 plus or minus 1.3 p.t.b., giving recovery of 94.7 percent of the known salt content and reproducibility within approximately 0.5 percent.

In the third experiment in Table 7, the residual oil from extraction by the experimental procedure was subjected to three additional extractions, yielding the following results: second extraction 7.0 p.t.b., third extraction 2.6 p.t.b., fourth extraction negative. These recoveries, added to the salt recovered by the first extraction (corrected for evaporation loss of oil), give a total recovery of 234 p.t.b., which is within 2 percent of the known original salt content. The two extractions by the Petreco L. B. method averaged 228 p.t.b., which is 95.5 percent of the known salt content and within 1 percent of the average of the three determinations by the experimental method. The Blair method, on the other hand, recovered less than 78 percent of the known total salt content, and the ashing method recovered less than 15 percent of the total.

In an effort to improve the percentage recovery of salt by the experimental extraction method, without the necessity for laborious repeated extractions of the oil, the number of emulsifying strokes employed in this method was increased from 30 to 50. In two sets of tests, the total salt recovery in a single extraction was increased by an average of 1¼ percent to a total of 96 percent of the known content. As this constitutes an appreciable improvement, the extraction procedure previously described was modified to employ 50 strokes instead of 30.

As a final check on the comparative value of a number of salt extraction methods, six methods were tested on four widely different oils. The oils employed are identified in Table 8, together with their pertinent characteristics and the results of their analysis for chlorides by the Mohr method. The extraction methods employed were as follows:

1. Petreco Experimental Method. This method has been described in detail above under the heading "Experimental Extraction Procedure". As also previously stated, final specifications for emulsification procedure prescribe 50 strokes instead of 30.

2. Petreco L. B. Method. This method, which has been the "standard" procedure in the company's Long Beach laboratory for nearly two years, is as follows: Mix 50 ml. benzol, 50 ml. oil, 25 ml. acetone, and 75 ml. distilled water in graduate; heat to 140°F.; emulsify thoroughly with tight-fitting piston; transfer to centrifuge tubes; rinse graduate with acetone and add rinsings to tubes; reheat tubes to 140°F., and centrifuge ten min. at 1800 r.p.m. If any emulsion remains, repeat heating and centrifuging, adding a small amount of a 10 percent benzol solution of Tretolite L-10396,

TABLE 7

Extraction of Synthetic Salty Oil

Signal Hill oil D-795—NaCl 239 p.t.b.

Exp. no.	*Procedure*	*NaCl found, p.t.b.*	*Recovery, percent*
1.	Petreco experimental method	227	94.9
2.	Petreco experimental method	232	97.1
3.	Petreco experimental method	235	98.2
4.	Petreco L. B. method (*)	232	97.1
5.	Petreco L. B. Method (*)	224	93.9
6.	Blair method[15] (modified by centrifugal separation of oil and water)	186	77.8
7.	Ashing	35.0	14.7

(*) Method subsequently described.

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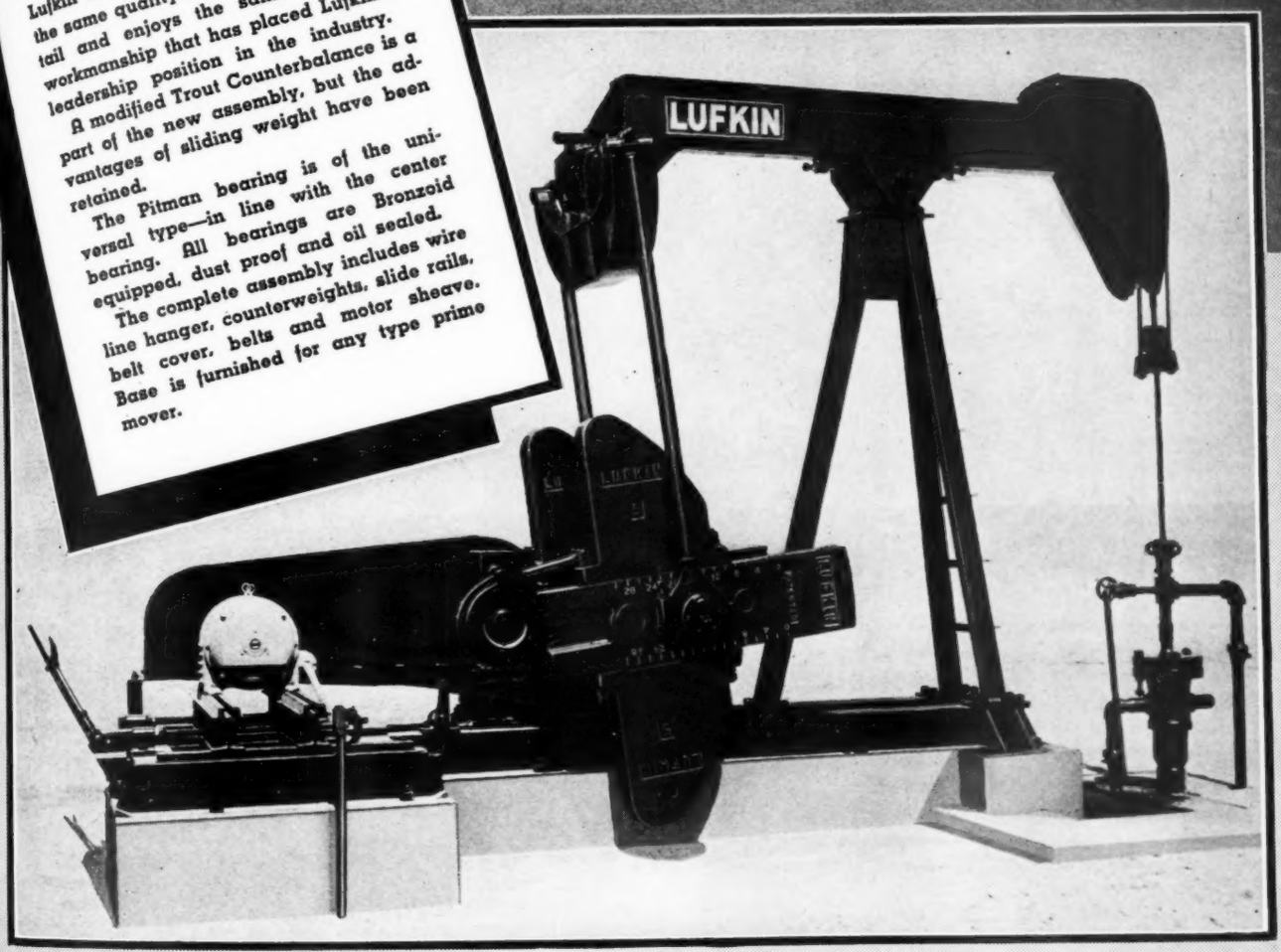
The new LUFKIN TC-55-7A unit assembly is believed to be a "Natural" for a small, but very economical and substantial unit for shallow production. Designed after the fashion of the larger Lufkin units, this assembly is made of the same quality materials in every detail and enjoys the same degree of workmanship that has placed Lufkin in leadership position in the industry.

A modified Trout Counterbalance is a part of the new assembly, but the advantages of sliding weight have been retained.

The Pitman bearing is of the universal type—in line with the center bearing. All bearings are Bronzoid equipped, dust proof and oil sealed.

The complete assembly includes wire line hanger, counterweights, slide rails, belt cover, belts and motor sheave. Base is furnished for any type prime mover.



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pipette water from tubes and filter, fill tubes with benzol, heat, and recentrifuge. The residual B. S. & W. should be less than 0.5 percent if separation has been good. If emulsion is greater than 0.5 ml., add a small amount of a 10 percent benzol solution of Tretolite L-10396, shake, recentrifuge, and add recovered aqueous extract to first extract.

3. Petreco Houston Method. This method was developed in our Houston laboratory to meet requirements for a rapid and accurate method for plant control tests. This method is as follows: 25 ml. of the oil sample are measured into a 100 ml. centrifuge tube (preferably by a pipette, which may then be rinsed with the benzol to be added), then 25 ml. of benzol and 50 ml. of distilled water are added. Only the oil sample need be accurately measured. One drop of a suitable demulsifying compound, such as the Tretolites X-20 or L-10396, is added to the mixture, and the tube is heated in a water bath to about 140° F. and then vigorously shaken for one min. The heating and shaking procedure is repeated several times. The tube is then centrifuged and the water layer removed either by a siphon or by a separatory funnel. A second washing of the oil is then made by adding 50 ml. of water and again shaking the mixture vigorously. The water layer is then withdrawn, the two aqueous extracts combined, and the chlorides titrated. Attention is invited to the fact that this is a dual extraction method, which imparts to it the high efficiency observed.

4. Barnsdall Method, as published by Puckett[7]. In this method a hot mixture of oil, benzol, and distilled water is shaken ten min. in a separatory funnel, transferred to centrifuge tubes, heated if necessary, and centrifuged, an aliquot part of the aqueous extract being taken for analysis.

5. Universal Oil Products Method, as described in U.O.P. Handbook[10]. In this method a hot mixture of oil, benzol, acetone, and water is shaken for a total of six min. in a separatory funnel and is then permitted to settle until separation is virtually complete, the entire aqueous extract being taken for analysis. This extraction procedure is repeated if necessary on the same oil sample, but not more than three extractions are allowable.

6. Blair Method, recently published[15]. In this method a hot mixture of oil, xylol, distilled water, and a chemical destabilizing agent is shaken five min. in a separatory funnel and is then permitted to settle until separation is complete, an aliquot part of the aqueous extract being taken for analysis.

Of the above methods, numbers 4, 5, and 6 have been published in detail elsewhere, hence only brief qualitative descriptions of those methods have been included here. Methods 1, 2, and 3 have been described in detail because they have not been published heretofore.

In examining the data presented in Table 8, it is seen that, in general, extraction procedures employing solvents and demulsifying chemicals together with centrifugal separation result in the most nearly complete extraction of the salts from the oil. It is also observed that the U.O.P. method gives good results when the triple extraction procedure is followed. If, however, only one extraction is performed, as will often be the case, then the percentage recovery is materially reduced, and, what is more important, becomes erratic, varying from 65 percent to 96 percent. The Barnsdall method is low in every case, whereas the Blair method gives good results in all cases except that for which the demulsifying agent was apparently unsuited.

It is interesting to note how closely the procedure of the experimental method parallels that of the older Long Beach laboratory method, despite the fact that the two were developed entirely independently and from different experimental backgrounds. As evidenced by comparison with data in Table 7, both these methods can be depended upon to recover at least 95 percent of the total salt content of an oil, and results by either method are reproducible to 1 or 2 percent. By repeated extractions, the salt recovery can be made to approximate 100 percent.

TABLE 8

Summary of Salt Extraction Methods

Oil used	Michigan		California		Kansas		Texas	
Laboratory sample number	D-755-6		D-722		D-428		B-397	
Dry oil gravity, °A.P.I. at 60°	33.5		23.0		38.5		22.0	
Dry oil cut, percent B.S. & W.	0.4		3.2		1.6		6.4	
Extraction method no.	*NaCl, p.t.b.*	*Recov., percent*	*NaCl, p.t.b.*	*Recov., percent*	*NaCl, p.t.b.*	*Recov., percent*	*NaCl, p.t.b.*	*Recov., percent*
1. Petreco Experimental Method	256.8	98.3	416	100	52.3	93.7	801	98.8
2. Petreco L. B. method	254.3	97.3	416	100	53.1	99.6	811	100
3. Petreco Houston method	261.3	100	-----	-----	53.3	100	811	100
4. Barnsdall method	163.4	62.5	117.3	28.2	43.9	82.4	724	89.3
5. U.O.P. method—								
first extraction	232.9	89.1	272.0	65.3	41.5	77.9	784	96.7
second extraction	-----	-----	132.0	31.7	10.5	19.7	20.2	2.5
third extraction	-----	-----	0.7	0.2	1.1	2.1	0.2	Neg.
total extraction			404.7	97.2	53.1	99.6	804	99.1
6. Blair method	252.3	96.6	124.5	29.9	49.9	93.6	762	94.0

Of the six methods tested, the three Petreco methods are the only ones that uniformly and dependably extract a satisfactorily large percentage of the salts from the oil. On the basis of percentage salt extraction, there is little choice, and all three methods are equally suitable. These methods have been tested on a wide variety of oils, have been found to be free from operational difficulties, and are shown to give accurate and dependable results. They are, therefore, recommended as being widely applicable in the determination of salts in crude oils.

Inasmuch as the recommended procedures all prescribe centrifugal separation, the point may well be raised as to procedure if no centrifuge is available. In such a case it is recommended that the Petreco Long Beach method be used with the modifications that the volumes of the components be doubled and gravitational separation in a 750 ml. separatory funnel be substituted for centrifuging. Repeated extraction may be required to insure complete salt recovery.

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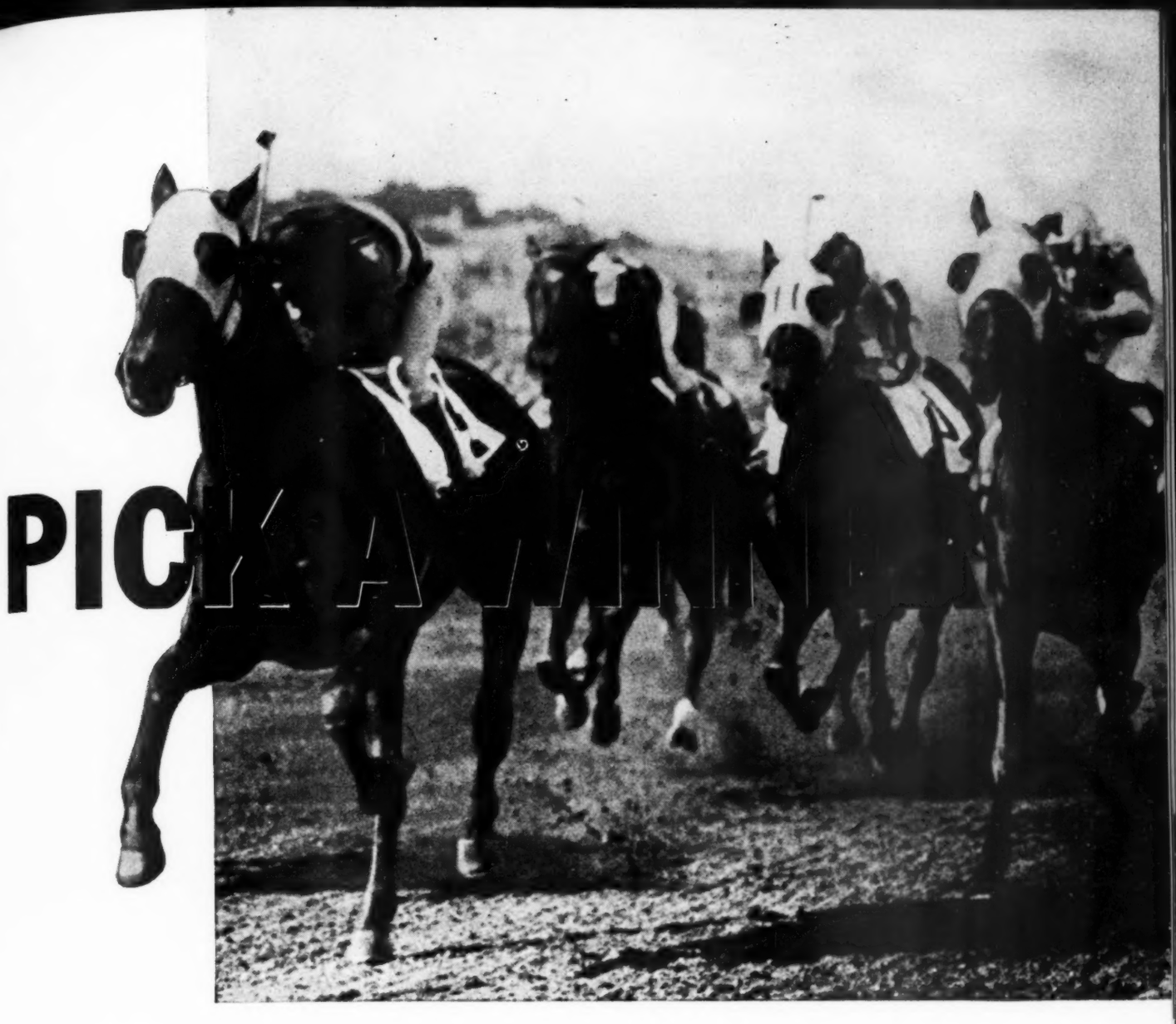

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Economies Result From Use of Drill-Pipe Protectors in Drilling Open Hole

Wear on tool joints and "whipping" of drill pipe are greatly reduced, and thus the service life of the drill stem is prolonged

By WALLACE A. SAWDON

THE use of protectors placed on the drill pipe for protection of the casing within which the drill string rotates and of the drill pipe itself has long been standard practice among most operators who have consideration for the ultimate life of the casing. Recently, considerable study has been given to the possible value of protectors on the drill pipe in open hole, especially in deep wells such as are now being drilled, in some of which as much as 10,000 ft. of open hole is being carried. Protection in open hole may be required for the tool joints, on which the abrasive action of some formations causes excessive wear; in some wells protection against whipping may be necessary, and in some wells it may be desirable to protect against both wear of tool joints and whipping.

Owing to the severe abrasiveness of formations encountered in the new Coalinga Nose district, an excellent opportunity has been presented for determining the results that may be expected from the use of protectors on drill pipe in drilling through open hole. The surface string is here set at depths of 500 to 1000 ft. and open hole is carried to a depth of almost 8000 ft. The formation is a hard, sandy, sharp, cutting shale, which is drilled by rock bits and is said to be very tough. In some of the wells previously drilled the tool joints had to be refaced every five weeks and after refacing five times had to be discarded. At each well about 300 ft. of drill pipe was junked and a drill string would drill about five wells.

Protectors suitable for service in open-hole drilling require a very high-grade, resilient, uniform stock to provide tensile strength and resistance to abrasion. They must not be subject to permanent set and must be able to stand abuse without chipping. After developing a special grade of rubber uniformly cured throughout its entire thickness to meet these requirements, and after designing a protector especially for open hole drilling, Patterson-Ballagh made arrangements to conduct performance tests in Robert S. Lytle Well No. 71-18-F in the Coalinga Nose district in coöperation with H. H. Dievendorff, drilling superintendent for the oil company. These tests were made to determine the wear on tool joints and protectors and the effect of whip and other factors influenced by the use of protectors on the drill pipe.

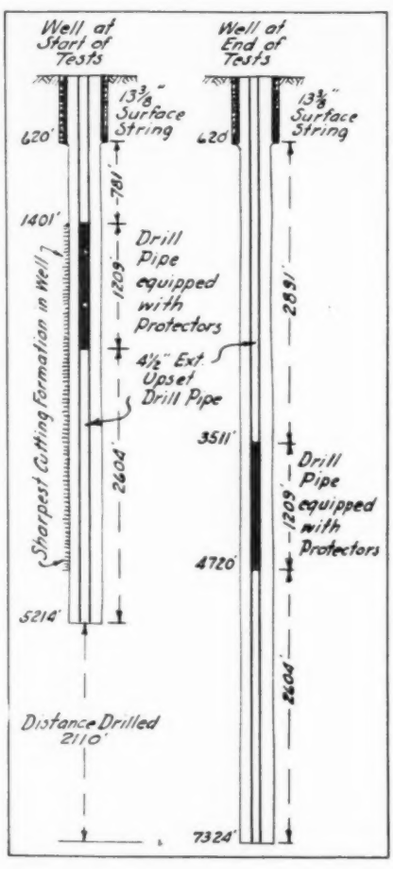

Fig. 1. Portion of drill pipe on which protectors were installed

These tests were started on December 20, 1938, at a depth of 5214 ft. and completed January 12, 1939, at 7324 ft. The subsurface conditions are indicated in Fig. 1 and, as here shown, only a 1209-ft. section of the drill pipe was equipped with protectors. The protectors were purposely installed opposite what operators asserted to be the sharpest cutting formation in the well. In drilling the 2110 ft. of hole from 5214 ft. where the tests began to 7324 ft. where they ended, 368.5 hours was consumed in actual rotation, establishing a rate of 5¾ ft. per hour.

The 1209 ft. of protected drill pipe started at stand No. 28 and ended at stand No. 40; it thus extended from 2604 ft. to 3813 ft. above the bottom of the drill string. There was 781 ft. of unprotected pipe in open hole above the protectors at the start of the test and 2891 ft. at the finish. The hole drilled was 12¼ in. in diameter and the drill pipe used was 4½-in. Hydril external upset.

The results of the tests are shown graphically in Fig. 2, the top curve showing the wear on the tool joints and the bottom one the loss in diameter of the protectors. In Zone 1 (indicated on the curves), one protector was placed on each stand; in Zone 2, one protector at the middle of alternate joints; in Zone 3, one protector in the middle of each joint; and in Zone 4, two protectors were placed in the middle of the lowest joint of each stand. By these various arrangements data on different arrangements of protectors were obtained.

During the period of the tests 21

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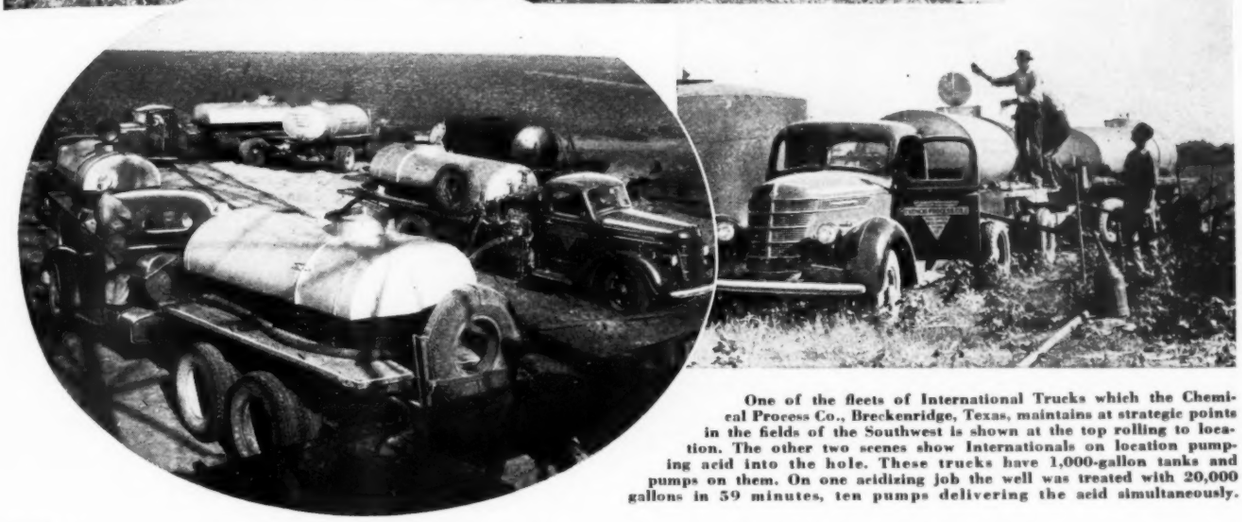

One of the fleets of International Trucks which the Chemical Process Co., Breckenridge, Texas, maintains at strategic points in the fields of the Southwest is shown at the top rolling to location. The other two scenes show Internationals on location pumping acid into the hole. These trucks have 1,000-gallon tanks and pumps on them. On one acidizing job the well was treated with 20,000 gallons in 59 minutes, ten pumps delivering the acid simultaneously.

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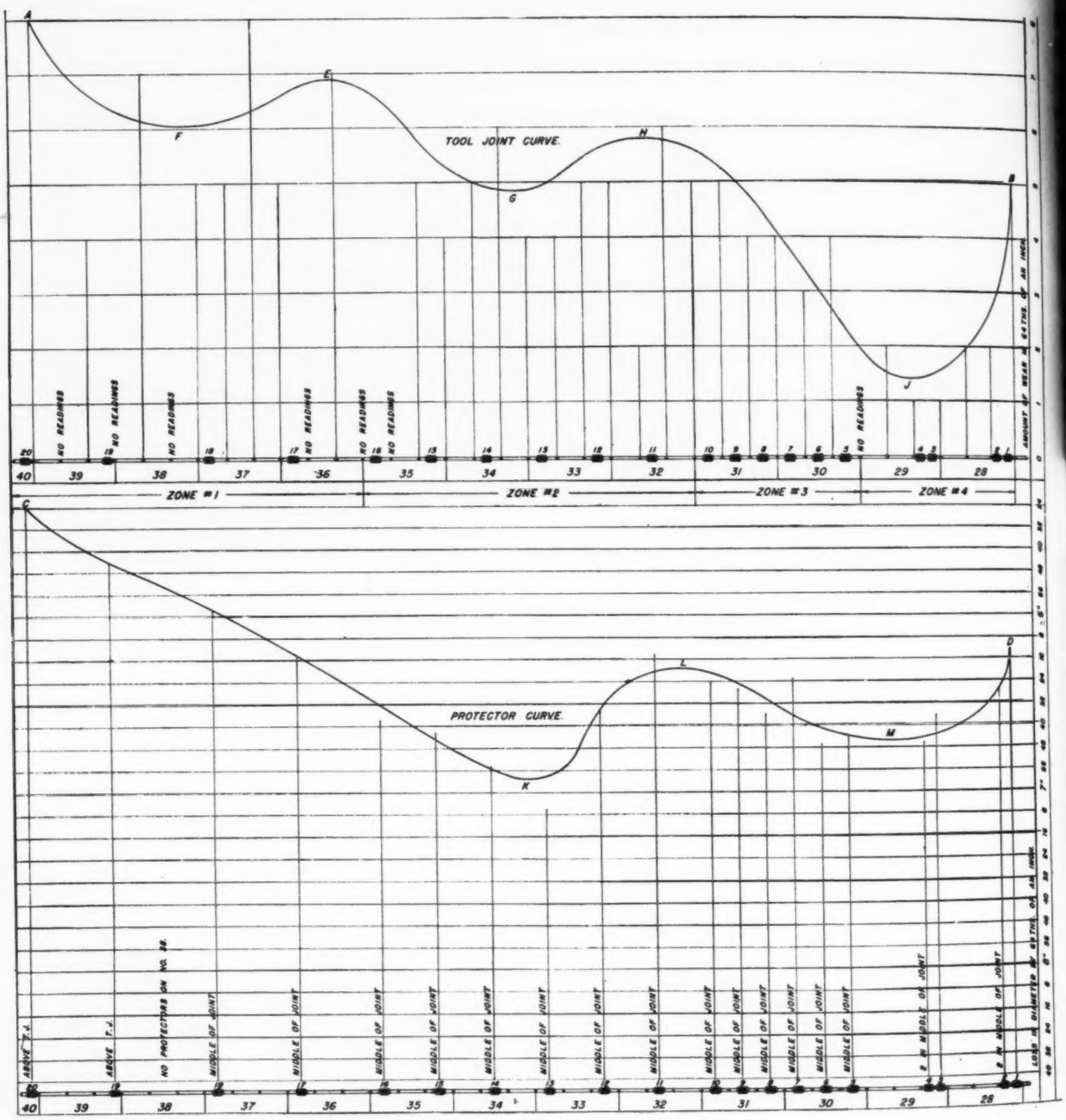
readings were taken. At each reading the loss in diameter of the protectors was measured in 64ths of an inch. The diameter of the tool joints was measured in 64ths at the start, during the tests, and at the end of the run. From the measurements made at the 21st reading the curves in Fig. 2 were compiled.

Observations made upon completion of the tests showed that there were no vibration marks on the drill pipe in the protected section and that the drill pipe showed less polish in the fully protected zones than in those where protectors were not used. The tool joints in the entire protected section wore longer than in the unprotected portion of the string.

The protectors themselves wore smooth, without chipping or cutting. Slippage of protectors was negligible although No. 20 on stand No. 40 moved upward a few feet after 22 days. This protector was cut away but the rest of the protectors remained at their original location. The protectors farthest apart and those adjacent to unprotected pipe were slightly barrel-shaped and thus indicated a tendency of the drill pipe to whip. Those in closely protected zones were worn evenly along their full length and indicated that whipping was reduced by placing the protectors closer together. Both types of wear are shown in the illustrations. (Fig. 3.)

No trouble was experienced in going into or coming from the hole. The drillers reported a slight reduction of torque, somewhat smoother drilling, and less tendency to stick the drill pipe, the last probably the result of

Fig. 2. Chart showing extent of wear on tool joints and protectors



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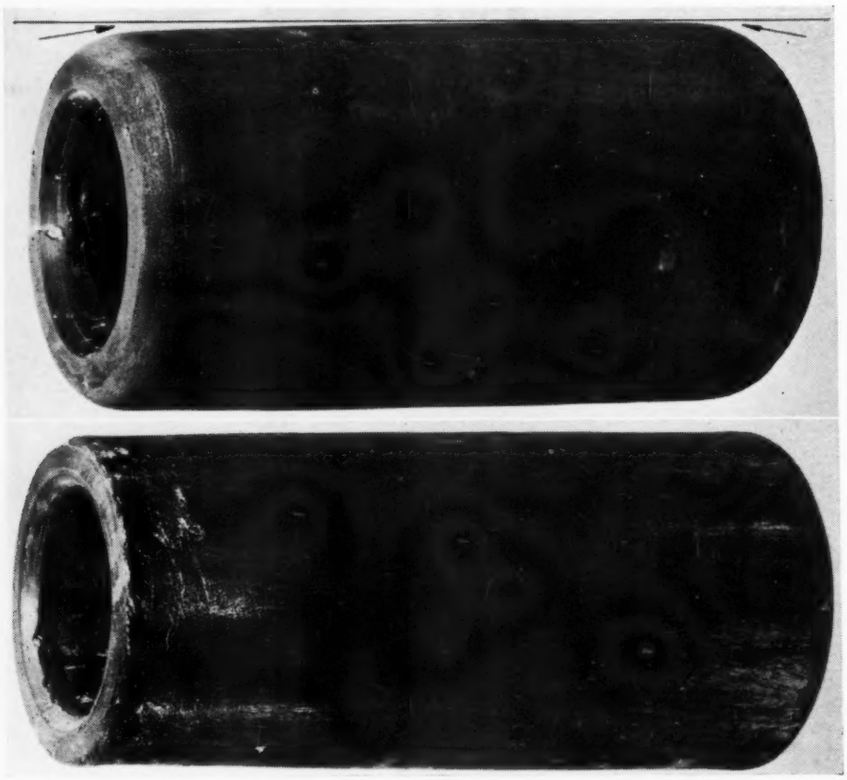


Fig. 3. ***Upper*****—Protector from upper zone after test, the barrel shape showing that the drill pipe was whipping.** ***Lower*****—Protector from center zone, where protectors were close together. Wear straight across without any rounding of corners indicates that there was no whip in this zone**

less inclination to "keyseat," because the pipe was held away from the wall of the hole. These statements were not confirmed and in view of the small number of protectors installed no attempt was made to verify these features.

The advantage of protecting all the drill pipe where abrasion will cause wear is demonstrated by the longer life of protectors and tool joints in the center of the protected section shown by the low points F, G, J, K, and M. This is further evidenced by the greater wear on tool joints and protectors that adjoin the unprotected section of the string, as shown by the high points at A, B, C, and D.

Where two protectors were used per joint, the tool joints on the inside of the protected section wore longest, as shown by point J. The protectors in the center of the entire protected section evidently wore longest, as shown by point K. This would indicate an advantage in protecting the entire string and would indicate further that wear caused by whip would be reduced. Protectors evidently wear longest if the entire string is evenly protected, whereas tool joints last longest if the rubbers are close together, as indicated by the fact that low point K does not coincide with low point J.

Conclusions drawn from these tests were that for maximum benefit the entire protected section should be provided with one protector per joint, preferably two; the best locations for protectors are one at the center of the joint and one just above the tool joint; that tool joints hold gauge longer when the drill pipe is protected, as the wear is absorbed by rubber rather than by the tool joint, and that whip can be reduced by the use of protectors. The protectors used in the tests were originally 8⅝-in. O.D. but wore rapidly to 7½-in., beyond which point the wear curve flattened. It was also concluded that on 4½-in. drill pipe drilling in 12¼-in. hole a protector of a diameter exceeding 7½ in. is not economical for long protector life. If conditions dictate maximum stabilization, a greater diameter may be needed in spite of greater wear.

There seemed to be no indication that the protectors caused excessive swabbing action any more than when used inside casing. There is a possibility that they assisted in mudding the wall of the hole. The advantage in prolonging the life of the tool joints by decreasing the wear is evident. By reducing the whip, and by damping the blows by the rubber, the protectors tend to reduce metal fatigue. Among the advantages of reducing whip of a drill string are: increased life of drill pipe; increased drilling speed, especially at "critical-speed"; decreased torque, reducing the danger of "twist off"; smoother drilling, which should increase life of bits and allow longer time in the hole; reduced tendency of tool joints to unscrew and "wash-out," which should greatly increase drilling safety; reduced bending of drill pipe, and less breakage of drill pipe, because of less "fatigue."

These and other tests indicate that the life of protectors when used in open hole and installed two to the joint is 350 to 450 hours. This should be enough to outlast the "trouble zone" in most 10,000-ft. wells. The character of the formation and the drilling technique used will naturally have too much influence to permit any general estimate of protector life.

In addition to the saving in drill pipe as the result of protecting the pipe against wear, other factors of economy that may result from the use of protectors on drill pipe in open hole are: increased speed in drilling; increased production because of earlier completion; decrease in tool-joint cost per well; reduction of delay for building-up tool joints; decrease in fishing jobs; increase in the footage per bit; decrease in "washed-out" tool joints, and other minor benefits.

Drill pipe operating in some open holes may not need protectors at all; in others it may require them for only a part of the total depth. Prevention of whipping, however, may sometimes make protectors economical even when the formation drilled is not excessively abrasive. Each drilling well is a separate problem that must be considered as such.

P 214.21
P 771.

Special Vapor-Pressure Bomb for Demonstration of Vapor-Liquid Relationships

Study of measurement of gasoline vapor pressure is facilitated by modified Reid apparatus

By J. A. CAMPBELL

Vice-President and Chief Engineer, Lomita Gasoline Company

THE purpose of this article is to clarify some points that puzzle some of the men who use the Reid Vapor Pressure Bomb daily in gasoline plants and refineries all over the country.

The vapor-pressure test is used as an indication of the volatility of gasoline. Motor fuel must have the proper degree of volatility to facilitate starting and insure propagation of flame through the explosive mixture. Should the volatility be excessive there is danger of gas-lock. Carburetors of automobile and other gasoline engines are designed with small jets intended to admit the fuel in liquid form. If the fuel is so volatile that the heat of a motor, which of course is greater in hot weather, is sufficient to vaporize the fuel in the fuel line ahead of these jets in the carburetor, the motor will die from starvation. A gallon of gasoline will evaporate to approximately 25 cu. ft. of vapor and as 1 cu. ft. equals approximately 7½ gal., it is evident that the material in vapor form occupies a space more than 180 times as great as it does in liquid form. Conversely the liquid form carries 180 times as much power as the same volume of vapor. When the vapor forms back of the jets and is struggling to get through, the liquid is choked-back and the motor coughs and spits and dies for lack of fuel. Only a small amount of liquid need vaporize to produce this effect, so it is important that volatility be controlled.

The apparatus adopted by the industry as a means of measuring this volatility is the Reid Vapor Pressure Bomb. It consists of a lower gasoline chamber approximately 2 in. in diameter and 2¼ in. high and an upper air chamber of the same diameter and 10 in. high. The two are connected by a tight, threaded joint. In natural-gasoline plant practice the gasoline is usually stored in pressure vessels, and a bomb sample is taken under pressure and cooled to ice temperature. The lower chamber of the Reid apparatus is chilled in like manner and is filled with the cold gasoline. The object in precooling the small chamber is to prevent the flashing of any of the more volatile fractions to vapor, which would result from pouring the gasoline into the warm metal receptacle and would produce a lower reading. The upper chamber is placed in a bath at 100°F. and kept there until ready to attach to the lower chamber. The upper chamber is surmounted by an accurate pressure gauge of the proper range.

J. A. CAMPBELL

entered employ of Union Oil Company in 1917—Occupied at various times the positions of research engineer, construction engineer, superintendent of construction, design engineer, and engineer of gas plants. In 1923 accepted the position of chief engineer of the Lomita Gasoline Company, Long Beach, California, acquiring an interest in the company—In 1924 formed the J. A. Campbell Company and engaged in the design and construction of absorption plants for the next eight years—In 1932 retired from the contracting business to enter field of research and development. At the present time, in addition to being vice-president and chief engineer of the Lomita Gasoline Company, he is president of J. A. Campbell Company, manufacturing and development engineers, and an officer or director in five other companies engaged in various activities in southern California. Is a graduate of Ogden College and Yale University.

As soon as the lower chamber is filled with the cold gasoline, the upper chamber, the gauge attached, is firmly screwed to it. The apparatus is turned upside-down several times and shaken and then immersed to the gauge connection in a bath maintained at 100°F. After remaining in the bath several minutes to give the heat a chance to penetrate, the bomb is removed, inverted, and shaken again to create turbulent action to distribute heat from the bomb throughout the liquid and to mix the gasoline and the air thoroughly. The apparatus is again placed in the bath to restore any heat lost during the agitation, and the reading of the gauge gives the "vapor pressure" of the gasoline. Some control chemists shake the bomb two or even three times.

Assuming that the gauge reads 21 lb., the product is said to be 21-lb. gasoline, and technicians state that this is the absolute vapor pressure of the product. This is what confuses the laboratory man. The gauge reads 21 lb. and in all his work in gas measurement he is used to adding 14.73 lb. to the gauge reading to get the absolute pressure. Here is the joker. The 21 lb. is gauge pressure but it is not the gauge pressure of the gasoline vapor, but the gauge pressure of a mixture of gasoline vapor and air. The air in the bomb, like all free air, is under an absolute pressure of 14.73 lb. This, of course, is different for different elevations but a pressure gauge gives a differential reading. The hand indicates the difference between the pressure inside the Bourdon tube and the pressure outside the tube; so, because the air inside the bomb is the same as that outside, there is no correction to make for atmospheric pressure. A Bourdon tube is made of thin, flexible metal and is curved. Naturally, there is more area on the outside of the curve than on the inside, and a unit pressure acting from the inside of the tube will tend to straighten the tube; one end being

fixed, the movement at the free end is transmitted mechanically to the hand. If a Bourdon tube is connected to a vacuum line, the greater total pressure on the outside of the curve tends to increase the curvature and the hand moves downward, recording a partial vacuum.

Dalton's Law states: "The quantity of vapor that can exist in any limited space depends on the temperature solely, and is the same whether that space be vacuus or occupied by another gas." Vapor pressure apparatus operates under this law, and the application of Dalton's Law is a controlling factor in virtually all gasoline-plant operations. Wishing to understand more clearly the application of this law, the writer built a modified Reid Vapor Pressure Bomb provided with two lower chambers and valves between and a connection for evacuating the upper chamber. The apparatus is shown in Fig. 1.

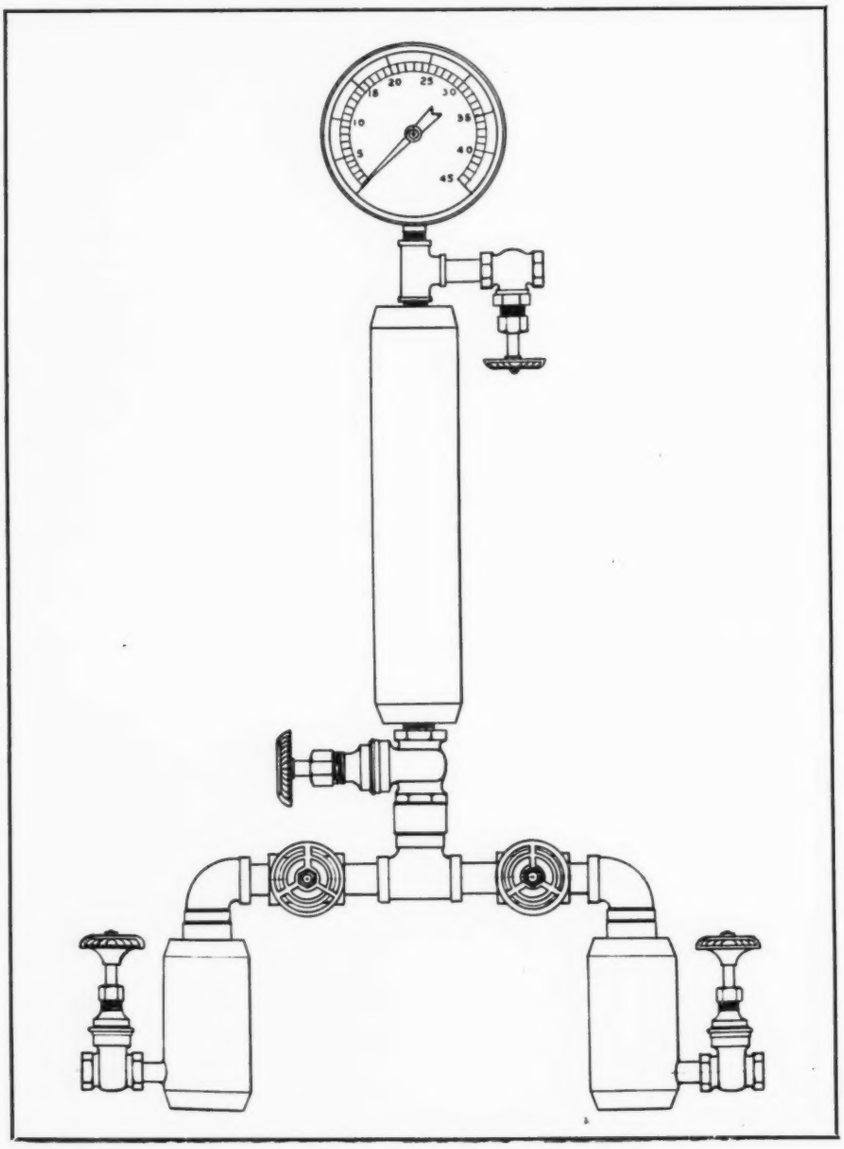
In order to use some highly volatile liquids that would cause serious danger of rupture from liquid expansion if the chambers were filled full of liquid against closed valves, the lower chambers were made 3 in. long and were filled only two-thirds full. To evacuate air from them, they were filled and then partly emptied. The two lower chambers were provided with ¼-in. drain valves. All valves were carefully ground and stuffing glands repacked and well tightened. The entire apparatus was then subjected to a hydrostatic test of 600 lb. per sq. in.

A large bomb sample of natural gasoline was first obtained from one of the pressure tanks. This supply was used in the whole series of tests. The regular Reid bomb test was run on this material and a reading of 21.8 lb. was obtained. Next, using just one chamber of the special apparatus and the same amount of gasoline as used in the Reid bomb, average readings of 20.4 lb. were obtained. Naturally this would be lower than the Reid vapor pressure because of the increased expansion space in the unfilled portion of the lower chamber and in the fittings and connecting nipples.

The upper chamber was next evacuated to 28.5 in. partial vacuum, the lower valve being tightly closed. For this test a combination pressure and vacuum gauge calibrated against the regular test gauge was used as the bomb gauge. The 28.5-in. vacuum was as low as the vacuum pump would produce. One lower chamber was filled with gasoline and attached to the upper chamber. The valve leading to the second chamber was, of course, tightly closed. The valve between the upper evacuated chamber and the lower chamber was now opened and the usual procedure followed, the gauge reading 7.5 lb. The corrected air pressure was 14.7 lb. absolute and subtracting this from 20.4 lb. gives 5.9 lb., which should have been the reading if a perfect vacuum had been produced in the upper chamber and if gasoline entirely free of absorbed air had been used.

The next move was to fill the entire apparatus with gasoline, using both lower chambers. The communicating valve to one chamber was closed and sufficient gasoline drained to leave the regular amount. A hose was connected to the drain valve of the other chamber and the valve opened, as were the valve between the chamber and the T, and the valve between the T and the upper chamber. The apparatus was then placed in the 100°F. bath, and the heating effect vaporized enough gasoline to force all the liquid from the apparatus through the hose, the lower end of which was held just beneath the surface of some gasoline. When bubbles stopped leaving the hose, the apparatus was full of gasoline vapor at atmospheric pressure and at 100°F. Next, the valve between the T and the chamber was closed and the one to the other chamber opened and the usual routine followed. The reading showed 7.3 lb. Deducting the atmospheric reading of 14.7 lb. from 20.4 lb. gives 5.7 lb. The discrepancy is due to the fact that the gas-gathering system operates under heavy vacuum and some air enters. Some of this air is absorbed into the oil, is released in the evaporator, and is again absorbed into the gasoline in the condensers. It is seen that both the gaso-

Fig. 1. Modified Reid vapor pressure bomb provided with two lower chambers and valves between and a connection for evacuating the upper chamber



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line and the gasoline vapor in the chamber above contain some air, which accounts for the higher apparent vapor pressure of the gasoline.

The next procedure was to fill the upper bomb with plant dry gas. The reading was 15.6 lb. This is much lower than the 20.4 lb. for air. "The quantity of vapor that can exist in any limited space depends upon the temperature solely, and is the same whether the space is vacuus or filled with another gas." Plant dry gas is never completely stripped of butane and iso-butane in normal absorption-plant operation, and these are the most volatile fractions in the stabilized gasoline; if the upper chamber contains some of these fractions in vapor form, diffused with the dry natural gas, less can be evaporated from the lower chamber and the crowding effect will not be so great. Consequently the pressure will not be so high.

These different tests were repeated and verified; the figures given are averages.

The results of these tests may be analyzed in the light of Dalton's Law. First, a comparison of the results obtained when the upper chamber was full of air and when full of gasoline vapor. By Dalton's Law, as the temperature was the same for each test, the same amount of gasoline vapor existed in the chamber. Note that *existed*, not *entered*. In the vapor test the upper chamber was already full of the same kind of gasoline vapor under one atmosphere, but the heat of 100° on the gasoline in the lower chamber created a vaporizing tendency that was great enough to overcome that one atmosphere, and additional vapor flowed into the upper chamber and increased the pressure to a point where it was sufficient to overcome the vaporizing tendency in the lower chamber and the vapor and liquid were in equilibrium for that temperature. What is of interest is that vaporizing tendency. What is measured is the vapor pressure, but the two are the same.

When the upper chamber was evacuated the same amount of gasoline vapor filled the upper chamber as in the other two tests, but considerably more gasoline evaporated and entered the upper chamber than when the test was started with vapor in the upper chamber. The same amount, however, except for slight discrepancies that have been explained, evaporated and entered as when air filled the upper chamber. That being true, one would think that the crowding effect would be the same and, consequently, the pressure rise the same. When air was used, the pressure was increased from zero to 20.4, which equals 20.4 lb. When vacuum was applied, the pressure was increased from minus 28.5 in., which equals minus 14.04 lb., to plus 7.5 lb., a difference of 21.54 lb., which results check very closely considering the error introduced by the residual air in the incomplete vacuum.

In the test starting with gasoline vapor in the upper chamber, the pressure increased only from zero to 7.3 lb., which is the gauge pressure of the gasoline. Adding one atmosphere to convert to absolute pressure gives approximately 22 lb., which is the vapor pressure of the gasoline-air mixture, or the absolute pressure of the natural gasoline.

From the results of these tests the laboratory control chemist can easily understand the variation due to absorbed air and the advisability of running vapor-tension tests on air-saturated samples, as recommended in the bulletin on vapor-pressure testing issued by the California Natural Gasoline Association.

It must be understood that the methods employed in conducting these tests were not scientifically accurate. The work was done in rather crude equipment in a gasoline-plant laboratory. The results, however, demonstrated the application of Dalton's Law. Great refinements were not justified because of the air content of the gasoline, the butane content of the dry gas, and the limitations of the vacuum pump. As A. J. du Bois, that dean of structural engineers, told his classes at Yale, "A consistent engineer will not multiply his diameter by 3.1416 to get his circumference until he is sure that he has measured his diameter accurately to the fourth decimal place."

In conclusion, the demonstrations show the Reid vapor pressure reading to be the absolute pressure of the gasoline being tested and the gauge pressure of the gasoline-air mixture.

S.A.E. SPECIFIES TEMPERATURE RANGES

IN the past there has been considerable disagreement between automobile manufacturers individually, between oil companies individually, and between both industries collectively as to the temperature ranges in which oils of different S.A.E. motor oil classification should be employed. At the request of both industries, the Lubricants Division of the Society of Automotive Engineers has given this question extensive consideration and has reached the conclusion that there are four temperature ranges for which motor oils of different viscosities are likely to be needed:

1. When the lowest expected temperature is minus 10° F.

2. When the lowest expected temperature is plus 10° F.

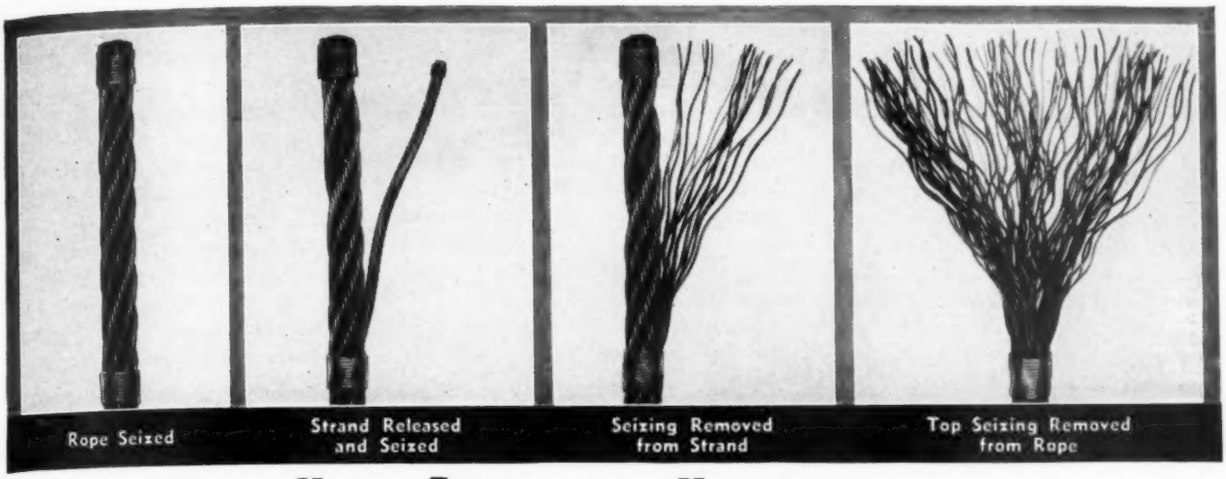
3. When the lowest expected temperature is plus 32° F.

4. When the expected daytime temperature is 90° F. or more.

These ranges, of course, correspond to very cold winter weather, normal winter weather, normal summer weather, and very hot weather. It must not be supposed that standardizing these four temperature ranges in any way suggests that four different oil viscosities are necessary to provide for all conditions of all equipment. This depends upon the design and construction of the engines, and also to some extent upon the nature of the oils employed. The basis is the axiom that in relatively cold weather an oil characteristic of primary importance is viscosity at starting temperatures, whereas in hot weather the viscosity of greatest importance is that at relatively high temperature, because it is this quality that influences oil consumption. Practically speaking, it is obvious that with this temperature set-up, two viscosities of oils will protect most engines in any particular territory. In parts of the South the normal seasonal ranges would be for a minimum of 32° F. and for a daytime maximum exceeding 90° F.; whereas in territories where minus 10° F. is a normal winter anticipation, temperatures exceeding 90° F. are most uncommon, and the two middle ranges cover by far the larger part of this country.

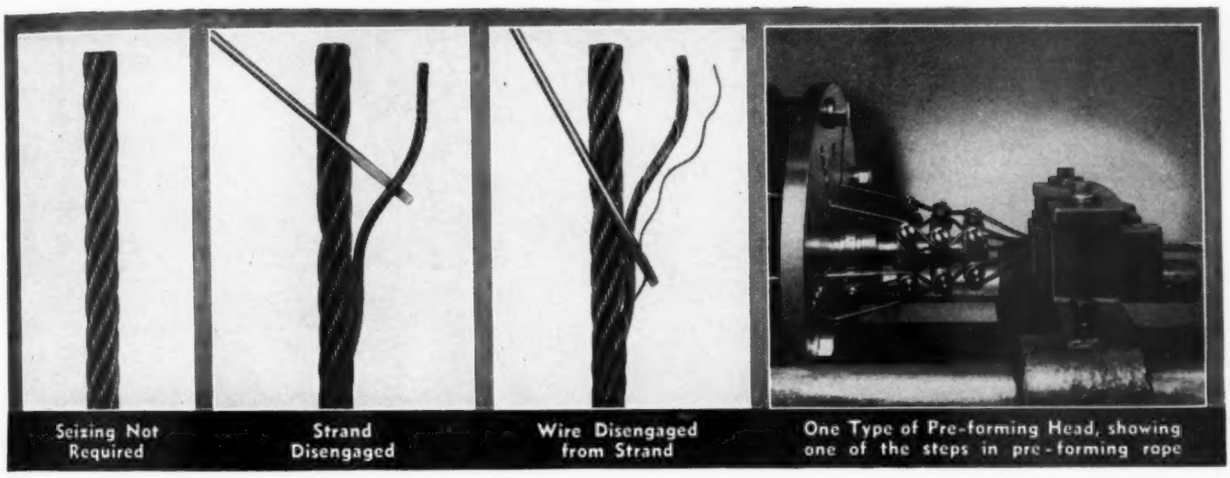
Virtually all automobile manufacturers are now using these ranges in their instruction books, and the same is true of most oil companies.

The DIFFERENCE ....



Rope Seized | Strand Released and Seized | Seizing Removed from Strand | Top Seizing Removed from Rope

between "*ordinary*" wire rope ...



Seizing Not Required | Strand Disengaged | Wire Disengaged from Strand | One Type of Pre-forming Head, showing one of the steps in pre-forming rope

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UNION

P 094.819

Simplified Boiler Efficiency Chart

By W. F. SCHAPHORST

THE accompanying chart indicates approximately the efficiency of a steam boiler based solely on chimney gas temperature and heat value of the fuel. Draw a straight line through the heat value of the fuel, line A, and the chimney gas temperature, line B, and read the boiler efficiency on line C. The dotted line drawn across this chart shows that if the heat value of the fuel is 12,000 B.t.u. and the chimney gas temperature is 600 deg. fahr., the boiler efficiency is about 68.8 percent.

In developing this chart averages of numerous authoritative tests in which the boiler efficiency ranged from 60 percent to nearly 80 percent were studied. The heat value of the fuel was considered in each case, together with the temperature of the chimney or exit gases, and this "rule" was derived: "Multiply the temperature of the exit gases in deg. fahr. by 625 and divide by the heat value of the fuel in B.t.u. per pound. Then subtract that from 100. The result is the approximate boiler efficiency in percent." Of course if the fire is poor, so that the gases contain a large percentage of CO, the rule naturally will not hold.

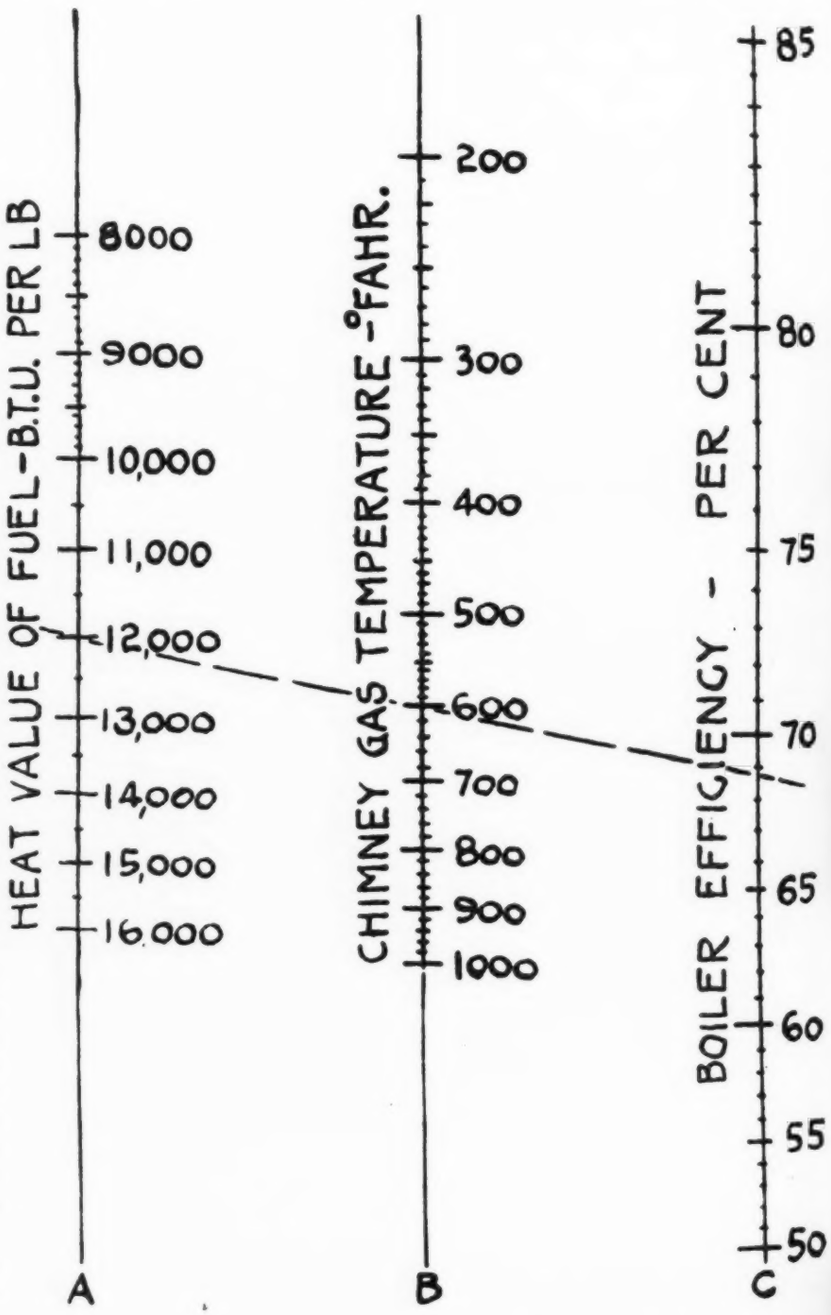
For example, what is the approximate boiler efficiency if the heat value of the fuel is 12,000 B.t.u. per lb. and the chimney gas temperature is 600 deg. fahr.? Apply the above rule and the result will be found to be 68.8 percent just as indicated by the dotted line through the chart.

The usual but much more complex procedure in determining boiler efficiency is to "find the heat in the steam evaporated by the boiler and divide it by the heat given up by the fuel." In other words, boiler efficiency, like all other efficiencies, is equal to "output" divided by "input".

Why bother about the steam, however, if we know the quantity of heat that escapes through the chimney? We conclude that the heat that does not escape is absorbed by the boiler. To determine the output, then, simply subtract the heat lost through the chimney from the original heat in the fuel. Divide that by the "input", or the heat in the fuel to determine the boiler efficiency.

Admittedly it is not easy to find the exact amount of heat lost up the chimney, but it can be done with a fair degree of accuracy if one knows the number of pounds of gas passing from the chimney in a given time. The trouble is that the quantity varies with the different fuels used and with different firemen. A first-class fireman using a CO_2 machine can regulate the flow of air until it is "just about right". Perhaps he will use 18 lb. of air per lb. of fuel — perhaps more — perhaps less. Eighteen lb. is usually regarded as satisfactory.

The chart will be valuable also for demonstrating the importance of maintaining as low a temperature in the chimney as possible. Thus, if the heat value of the fuel is 12,000 B.t.u., swing a straight line about that point on line A as a pivot. If you can reduce the temperature of the chimney gas 100 deg. the boiler efficiency will be found to be approximately 74 percent, or an increase of about 5 percent.



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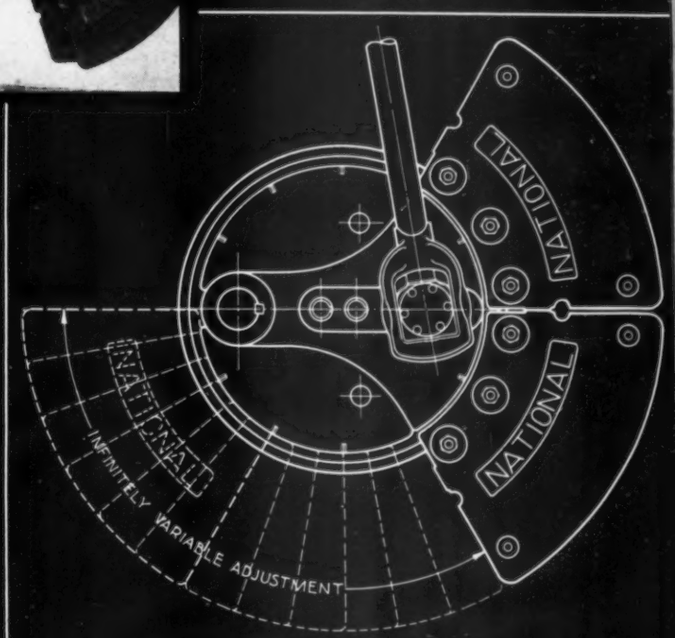

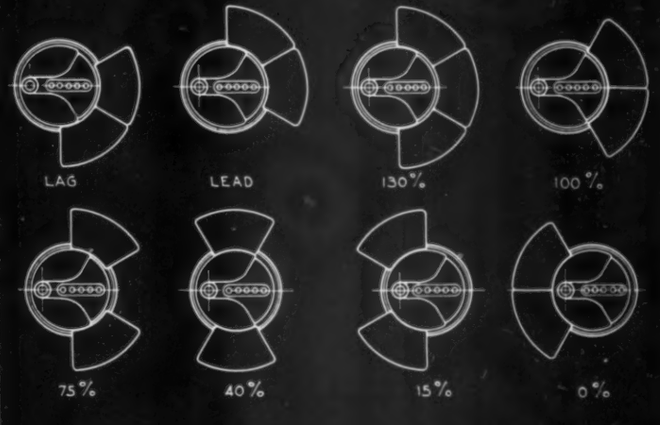

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P 094.867

Adaptation of Centrifugal Pumps To Different Duties

Versatility of centrifugal pumps permits their use for jobs of many different types provided conditions outside the pump are adjusted properly

By

REUBEN G. LOVELL

Development Engineer, Hancock Oil Company

THE range of the duties that can be performed by an electric-motor-driven centrifugal pump is much broader than is commonly believed.

Centrifugal pump manufacturers provide such a unit arranged to fulfill as efficiently as possible the service specifications under which it is to operate. They also supply a set of characteristic curves. These curves are based on actual tests, and a study of them will show clearly just what may be expected of any particular pump under any set of operating conditions different from that for which the pump is equipped.

The manufacturer, however, is limited in his design by certain inherent characteristics of a centrifugal pump. The conditions outside the pump itself are, in a very great degree, within the control of the owner or user of the pump. These outside conditions can, in themselves, have the effect of widening the field of application of the equipment to a much greater extent than is possible by changing any of the pump characteristics.

Consider a typical pumping problem and observe how a knowledge of the effects of these changes can not only make practical the use of existing equipment but also effect an appreciable reduction in operating cost.

First, the affinity laws that govern the action of a centrifugal pump must be known and thoroughly understood. They are:

1—The quantity discharged will vary directly as the speed.

2—Head will vary directly as the square of the speed.

3—Power will vary directly as the cube of the speed.

Assume a set of conditions likely to exist in any refinery. By use of these affinity laws it will be shown how an induction-motor-driven pumping unit can be adapted to an altogether different set of conditions. Assume that the name plate of a centrifugal pumping unit indicates that it is to be used to pump 200 gal. of water per min. against a total discharge head of 250 ft. The unit is equipped with a 20-hp., 3-phase, 1440-r.p.m. motor. Suppose there is no way of measuring the frequency of the electric current on which the unit had been operated. It is easily determined from the r.p.m. marking of 1440 by use of the simple formula:

$$\text{Synchronous speed} = \frac{120 \times F}{p}$$

wherein:

F = frequency in cycles

p = number of poles of the motor.

Induction motors will have a full-load speed of at least 96 percent of the synchronous speed.

Use of the following table will give the desired information at a glance. As 50 and 60 cycles are almost universally used only those frequencies are given.

Number of poles	*Number of cycles*	
	50	60
2	2875	3450
4	1440	1725
6	950	1150
8	720	865
10	575	690
12	425	575

From this table observe that the motor in question is wound and connected for 4 poles and 50 cycles.

For a clear understanding of the problem the indicated past duty and a desired duty of a different character are shown:

	Past	*Desired*
Material	water	gasoline
Specific gravity	1.00	.7467
Volume, g.p.m.	200	?
Head in ft.	250	?
Motor hp.	20	?
Current, cycles	50	60
R.p.m.	1440	1725

REUBEN G. LOVELL

received his academic training in New York, after which he served several years in the Engineering Department of the New York Telephone Company—Went to Bisbee, Arizona, in 1908 where he "cut his mechanical engineering teeth" in one of the first large power plants of the Southwest, that of the Copper Queen Mining Company, later the Phelps-Dodge.

He next went to Mexico where he remained until 1917 and returned to enter the military service for the period of the war—Returning to Mexico after the war he served the Alvarado Mining and Milling Company of Parral as general master mechanic for two years.

Lovell left mining and went into petroleum in 1920 with the Standard Oil Company of California and since that time has been continuously associated with the oil industry, chiefly in manufacturing. His engineering career has included a wide range of practical experience with mechanical and electrical equipment in both the mining and petroleum industries—Has specialized in pumps and pumping.

For many years he has been with the Hancock Oil Company of California at Long Beach and now devotes his time largely to process and equipment development — Has also been in charge for five years of the classes in the Oil Refining Division of the Trade Extension School operated by the City of Long Beach.

A simple statement of the problem is: What quantity of 58-deg. A.P.I. gasoline can be pumped without unduly overloading the motor?

The two factors that will govern this quantity will be the new shaft speed of 1725 r.p.m. and the specific gravity of the gasoline, which is lower than that of the water for which the pump was previously used.

Quantity is the major problem. *Quantity varies directly as the speed.*

$$\frac{1725}{1440} \times 200 = 240 \text{ gal. per min.}$$

An assumption must be made concerning the discharge line conditions in order to know what head will result from forcing 240 gal. of 58-deg. A.P.I. gasoline through the line per min. Assume:

Static head	60 ft.
Friction head due to 150 ft. of 2-in. pipe	273 ft.
Friction head due to five 2-in. std. ells	36 ft.
Total discharge head for water	369 ft.

Tables from which these figures are taken are based upon water but, as both water and gasoline have very slight viscosity, the only correction necessary is that for specific gravity.

Because of the greater speed, 40 gal. per min. more can be pumped than could be pumped before but the total discharge head, which varies as the square of the speed, will exceed the rated head capacity of the pump. Probably the head capacity of the pump can be increased to the required figure by use of an impeller of larger diameter, but this will amount to increasing the peripheral speed of the impeller, and some consideration must be given to the increase in power necessitated by this speed increase. As *power varies as the cube of the speed*, it is quite possible that the motor will not bear the load. It is necessary to determine whether the 20-hp. motor on the unit has sufficient power to pump 240 gal. of gasoline per min. against the head required, correction being made for the specific gravity of the gasoline, which is 0.75.

Using the standard formula:

$$\frac{\text{g.p.m.} \times \text{head in ft.} \times \text{sp. gr.}}{3960 \times \text{efficiency}} = \text{Brake hp.}$$

and assuming 65 percent as the pump efficiency gives:

$$\frac{240 \times 369 \times 0.75}{3960 \times .65} = 26 \text{ hp.}$$

This overload is too great to tolerate and in order to use the 20-hp. motor it would be necessary to make definite sacrifice in capacity by reducing the impeller diameter, thereby lowering the peripheral speed and bringing the total discharge head to the limit dictated by the power limitation.

These last alternatives are seldom desirable. Therefore, what can be done outside the pump and how much will it cost?

Replace the 2-in. line and five 2-in. standard ells with 3-in. line and, say, five 3-in., 45-deg. ells for example. From tables:

Static head	60 ft.
Friction head due to 150 ft. of 3-in. pipe	38 ft.
Friction head due to five 3-in., 45-deg. ells	15 ft.
Total discharge head for water	113 ft.

The power required to overcome this head would be: $240 \times 113 = 11$ hp. for water $\times .7467 = 8$ hp. for gasoline. This is, of course, an entirely theoretical condition and it is easily possible that the characteristics of the pump might prevent taking complete advantage of the reduced friction loss; but, in any case, there are still available several practical ways of determining approximately the theoretical power.

The differential in power cost, current costing $0.02 per kw-hr., would be:

26 hp. $\times .746 =$
19.4 kw. $\times .02 =$ $0.388 per hr.
8 hp. $\times .746 =$
5.8 kw. $\times .02 =$ $0.116 per hr.

$0.272 per hr.

Dividing the extra cost of the 3-in. pipe by this amount shows the additional cost to have been absorbed in six pumping days of 24 hours. Each day of operation against the reduced head after that period effects a saving of $6.50.

This comparison has not been exaggerated and is truly representative of the savings that can be obtained by removing unnecessary friction head from a centrifugal pump.

The definite relation between quantity, head, power, diameter, and speed must not be overlooked. Change in any one of these factors has a definite effect upon the others in the proportions given. To determine the combination of greatest value requires that all factors be given their proper weight. If every user of a pump would realize that a centrifugal pump operates entirely by imparting velocity to the fluid, he would recognize at once its versatility.

Information on Motor Gasoline Made Public by Bureau of Mines

SERVICE station gasolines in the various price classifications fall into definite groups with regard to octane rating, distillation range, vapor pressure, and other characteristics, according to a report for the summer of 1938 issued by the U. S. Bureau of Mines. The octane-number ratings as indicated by the range of 90 percent of the samples show a slight increase in all three grades of gasoline compared with the survey of the previous summer.

Gasoline survey reports are made semi-annually by the Bureau of Mines to give information as to the quality of gasolines sold generally throughout the United States. This information is desired by automobile designers to enable them to provide the best engines possible to take advantage of the characteristics given to the gasolines by the skill of the refiners. The reports also supplement surveys made by individual petroleum refiners who need to know the characteristics of gasolines being made by all other refiners so they can manufacture a product within the limits of uniformity required for satisfactory engine operation.

For more than 20 years the Bureau of Mines has reported periodically on analyses of gasolines sold to the general public at service stations throughout the United States. Recently these surveys have been made in coöperation with the Coöperative Fuel Research Committe, which is a joint activity of the Society of Automotive Engineers, the American Petroleum Institute, the Automobile Manufacturers' Association, and the National Bureau of Standards. The paper just issued in this series, Report of Investigations 3429, Coöperative Fuel Research Motor Gasoline Survey, Summer 1938, compiled by E. C. Lane, may be obtained without cost from the Bureau of Mines, Information Division, Washington, D. C.

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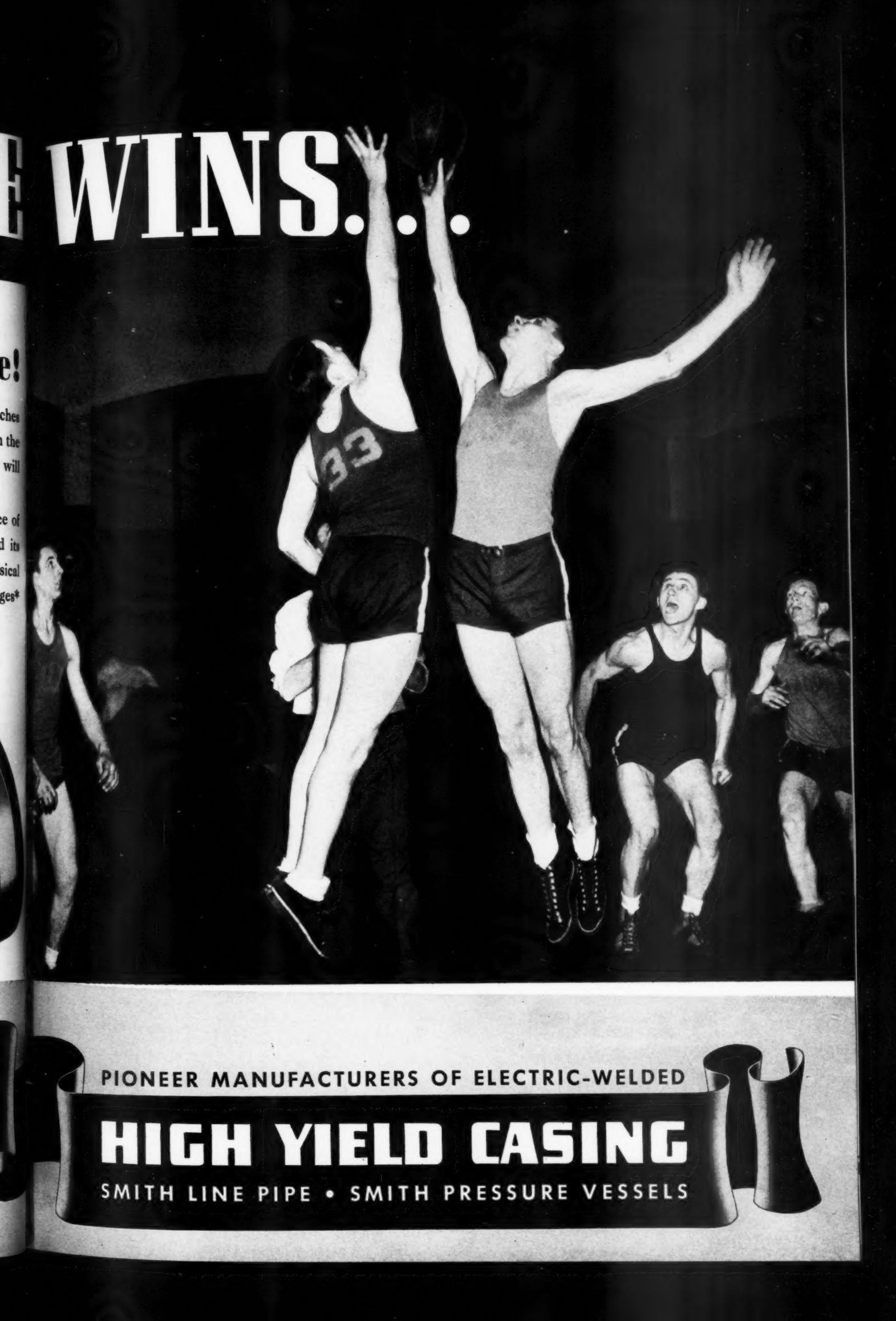
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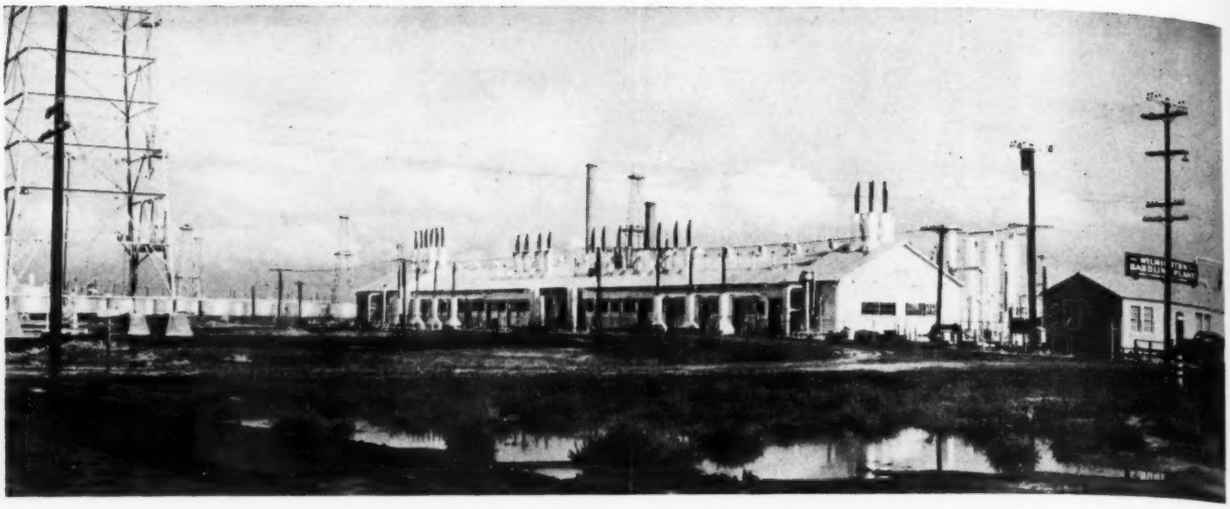


General view of Wilmington Gasoline Plant of General Petroleum Corporation

Sea Water Used to Cool Jacket Water and Products of Gasoline Plant

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Low bearing strength of "made" land necessitates use of piling for foundation of absorption plant in California

By J. C. ALBRIGHT

GENERAL Petroleum Corporation drilled the first well in the Wilmington, California, field, completing its No. 1 Terminal, at the corner of Ford and Badger Avenues, December 6th, 1936. The initial daily production was 1400 bbl. of 19-deg. gravity oil and about 325,000 cu. ft. of gas. The gas produced had a gasoline content of about 2½ gal. per M cu. ft., and the gasoline had a Reid vapor pressure of 20 lb. To extract this gasoline, General Petroleum Corporation built the first natural gasoline plant in the field.

As the greater part of the productive area in the Wilmington, Long Beach, and Los Angeles Harbor districts consisted of "made" land, formed from earth obtained by dredging and excavating channels and turning basins for sea-going vessels, the soil had a safe bearing support of about 500 lb. per sq. ft. It was therefore necessary to support all equipment on concrete-topped piling driven to a firm formation about 50 ft. below the surface. The load on piles supporting engines installed in the compressor room was limited to 15 tons per pile, including the weight of the concrete foundation blocks; piles supporting stationary equipment, such as absorbers, stills, heat exchangers, boilers, and direct-fired pre-heaters bore a maximum load of 20 tons per pile.

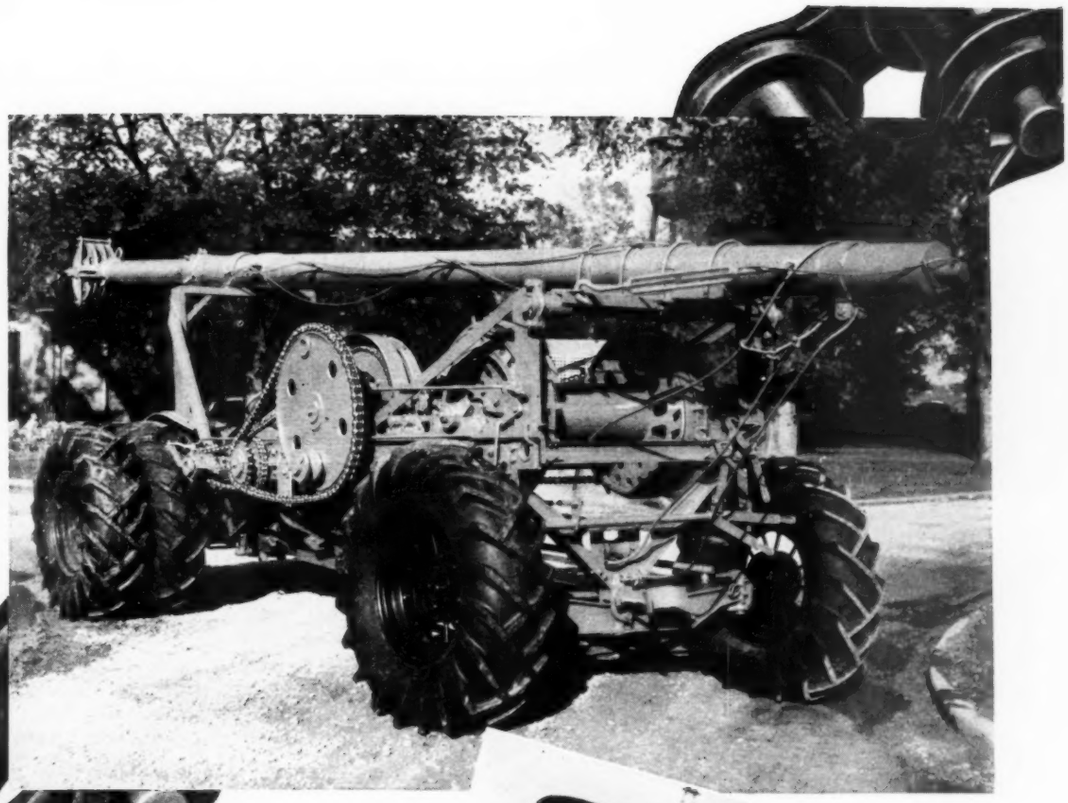
As the wells gave evidence of flowing for several years, field apparatus was installed to force the gas through the gathering mains under trap pressure instead of by compressor suction. On company wells traps were installed on steel structures, sufficiently high that the oil would flow to stock tanks and the gas would enter the lines at a pressure of about 6 lb. gauge. When the separators were elevated, it was observed that virtually all the desirable gasoline fractions required for plant operation would separate from the oil, thereby obviating to some extent the necessity for vapor-gathering lines from flow and stock tanks.

Because the gas comes from the traps under pressure, gathering lines smaller than ordinary were suitable and the amount of gas compressed by each compressor was increased proportionately. The gas companies purchase residue gas willingly, but require that it be introduced into their lines at pressures well above the standard 40 lb. generally utilized in absorption plants. This situation was a factor in the design of the compressor station.

Equipment installed in the Wilmington plant was moved from Santa Fe Springs, where the company had been operating one of the largest gasoline plants in California. Because of a marked decrease in gas production at Santa Fe Springs several engines, both 2- and 4-cycle, were standing idle. Piping was in excellent condition and could be moved to Wilmington at a

J. C. ALBRIGHT

after participation in the World War, was drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, in the natural gasoline and refining departments, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923 and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico as special representative at Artesia where the company constructed a natural gasoline plant—Made state representative by that company in 1926—Left Phillips in 1929 and for a time operated as a consulting engineer, having offices at Brownwood, Texas—For last ten years has devoted practically all his time writing as a free lance for trade journals.



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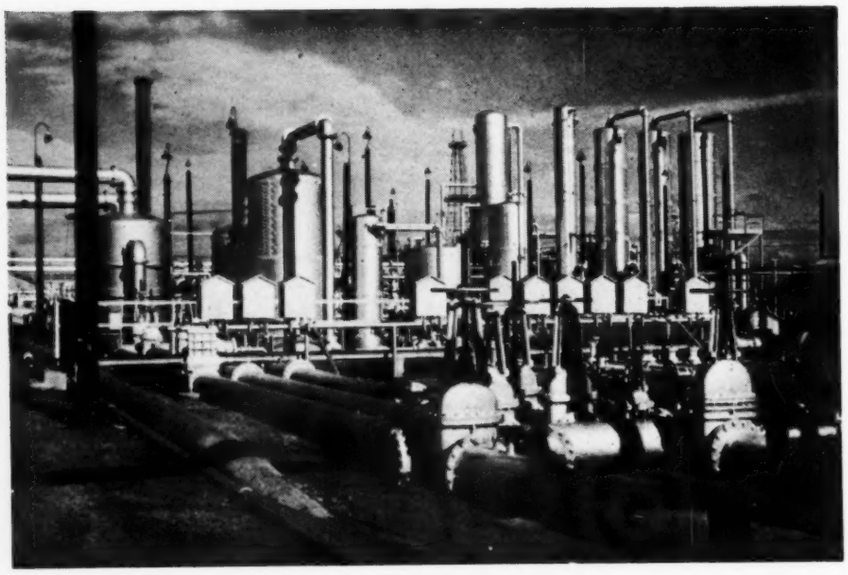


A system of back-pressure relief valves installed on manifolds automatically controls excess gas and relieves excessive pressure

cost below the salvage value. The 2-cycle engines were overhauled and converted from the exhaust-stool type to overhead exhaust and the original 16-in. power cylinders were replaced by 17-in., which simplified setting and provided more power per unit. The 4-cycle engines were reconditioned also. Both types were installed in the new plant upon the pile-supported concrete mat, blocks being poured for each engine.

The engine room was divided into two sections. The south end contained the engines for field loads, intake pressure varying from zero to 2 lb. gauge, and the north end of the building contained the high-pressure, or second-stage engines.

A system of back-pressure relief valves was installed on manifolds in the plant yard outside the compressor room to control automatically all excess gas and relieve excessive pressure. For example, if the field should produce a greater volume of gas than the low-pressure compressors could compress from 2-lb. intake to 40-lb. discharge pressure, the automatic release valve begins to vent the excess gas, and, no matter how many engines might become inoperative for any reason, the gas is released to the stack so that the predetermined intake pressure is not exceeded. Likewise, a release valve is installed on the discharge of the low-pressure field compressors to regulate the intake of the high-pressure compressors and the discharge of the low. Should all the high-pressure engines but one become inoperative, the pressure of the low-pressure gas would not exceed the 40-lb. limit. By this system of release valves, the compressors are completely protected from overloading. This arrangement obviates the necessity of "pinching" valves to equalize the pressure and balance the loads of several engines when a large volume of gas enters the plant.

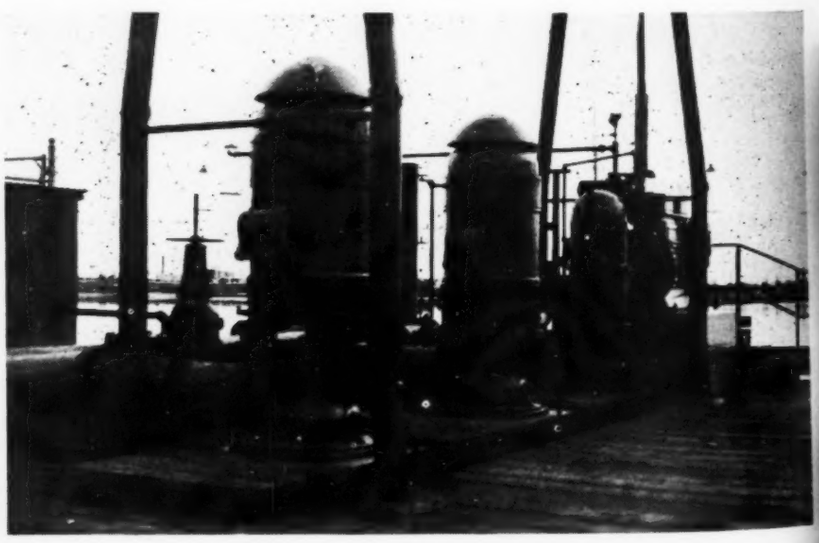
At this plant no provision was made for atmospheric cooling of engine-jacket water or commodities. Water is used for cooling the power and compressor cylinders and is treated to remove scale-forming minerals. Make-up is clean, oil-free condensed steam from the boiler battery. In enclosed shell-and-tube units adjacent to the engine room the jacket water is cooled by sea-water in a closed system.

In any gasoline plant the problem of obtaining an adequate supply of desirable water for cooling jackets and commodities is serious and frequently expensive. At Wilmington, however, the temperature of the water in the Long Beach deep-water channel does not fluctuate over a wide range, averaging throughout the year about 70°F., which is about 10°F. lower than might be obtained under the most favorable climatic conditions.

Directly south of the plant site, a pier was built into the channel upon which were mounted three deep-well turbine pumps, two of which are driven by electric motors, and one by a gas/gasoline engine. The motors have a rating of 75 hp. each, and the internal combustion engine 100 hp. The pumps were provided with sufficient submergence to take suction during extremely low tides, and were protected by a double screen to exclude marine organisms from the suction pipe.

The water system consists of an 18-in. pipe line from the pump discharge manifold to the plant cooling equipment, doubled for a distance of 300 ft. from the pumps to facilitate cleaning and to prevent the passage of barnacles from the channel to the plant. This doubled line is manifolded so that either section may be used, the idle section being filled with fresh water, which kills marine animals. Provision is made for blowing either section to flush out any foreign matter.

This comparatively cool sea-water flows directly through the plant commodity cooling units without intermediate pumping, the volume being controlled by gates. The warm, used water is directed into a 1000-bbl. skimming tank installed near the distillation control room. The tank is equipped with baffles that separate any oily



Deep-well turbine pumps used to pump sea water from the channel to the plant's cooling-water system

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HERE ARE THE FACTS

Casing Size: 9⅝"
Casing Weight: 43.50 lbs. per foot
Total Length: 11,632 feet
Total Weight of Casing: 505,296 lbs.
Started Running Casing: 6:30 p. m. Nov. 9
On Bottom: 2:55 p. m. Nov. 10
Total Time Running and Cementing Casing: 23 hours, 21 minutes
Floated: Last 3,000 feet
Maximum Weight on Indicator: 280,000 lbs.
Mud Data: At Time Casing Was Run:
Type: Baroid-Aquagel
Weight: 11.1 lbs. per gallon (83.0 lbs. per cubic foot)
Viscosity (Stormer Instruments at 600 r. p. m.): 23 centipoises
Viscosity (Marsh Funnel—1500 cc. in; 1000 cc. out): 51 seconds
Water Loss (Baroid Low Pressure Tester): 16 cc. in 30 minutes
Cake Thickness: 4-32 of an inch

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On the water system a 300-ft. section of double line facilitates cleaning the line and prevents passage of barnacles from channel to plant

liquid that might pass from the equipment to the tank. The tank overflows into a 24-in. vitrified-clay tile line, which carries the water to a different channel to avoid raising the temperature of the water at the pump suction.

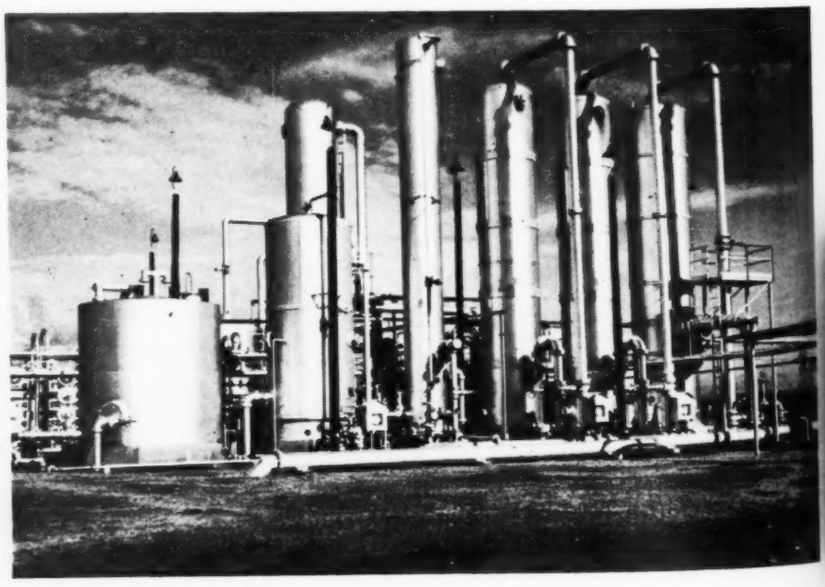
The electric pumps are equipped with remote-control instruments and change-over switches that function if the power in the high-line fails. A double circuit was provided to prevent power failure should power lines break. Under ordinary operating conditions, one of the motors and the gas/gasoline engine are operated simultaneously and the idle motor-driven pump is a spare. If either of the operating pumps fails, an alarm system connected with the water supply immediately flashes a red light on the board in the control room, indicating the difficulty. By punching a button, the plant operator immediately places the spare pump in operation.

Sufficient absorption oil is circulated through this plant by conventional methods to extract a maximum of 75,000 gal. of gasoline per day. The cold, lean oil enters the three high-pressure absorbers, operating at a pressure of 150 lb. gauge, above the top plate and descends over 17 plates. The rich oil from the base is vented directly into the base of a column termed the vapor absorber. Lean oil from the common circulating system enters this column above its 20th plate. The vapor absorber pressure is 20 lb. gauge. The undesirable gases dissolved in the oil from the high pressure absorbers are released, and the oil pumped over the top recovers any desirable fractions released with the undesirable gases.

From the base of this vapor absorber the oil flows at reduced pressure to a rich-oil vent tank, where some of the entrained vapors are allowed to pass from the oil at a pressure of about 6 lb. to the intake of the compressors for recycling. The rich-oil pump takes suction on this vent tank through automatic liquid-level-controlling instruments and delivers the oil through the distillation-system heat exchangers to a flash drum, where approximately 80 percent of the gasoline vapor is released. The oil enters the flash drum at a temperature of about 280°F. This method relieves the stripping section of the still of a large load, imposes small agitation steam load, and permits final stripping at low fuel cost.

From the base of the flash drum, the partly stripped oil is pumped to direct-fired preheaters, constructed like a skimming pipe still in a refinery. The oil flows through banks of tubes in the preheaters, where the temperature is controlled to that required for definitely removing all gasoline fractions recovered from the rich gas in the absorbers. At a temperature of about 375°F. the oil travels to the combination stripping and fractionating still. It enters at the mid-section above the ten stripping trays where it is processed, exhaust steam being used to provide agitation and reduce the vapor pressure. The ten plates in the lower portion of the still operate as partial fractionators, preventing the passage of absorption oil fractions to the upper section. The gasoline is fractionated in the upper section, also containing ten trays. Condensate from the gasoline coolers and accumulator drum is used as reflux in the ratio of two parts reflux to one part product.

General Petroleum Corporation maintains and operates a central fractionating plant within pipe line delivery distance to reduce the raw product by final fractionation to the quality and vapor pressure required for blending or for sale to other refiners in the Los Angeles Basin territory. The production in terms of total gallons depends upon the schedule of oil production of the field, which has been progressively reduced from the large initial volume per well to about 300 bbl., which naturally reduces the amount of gas available for processing.



The three high-pressure absorbers and the vapor absorber

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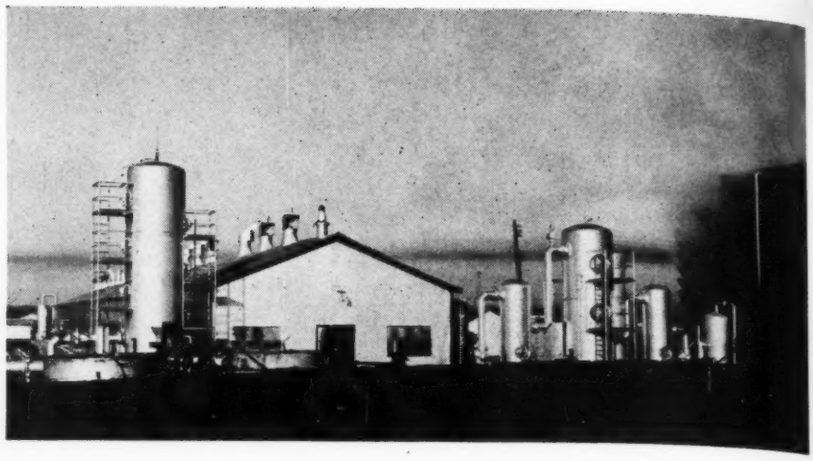
Fig. 1. Breckenridge treating plant of Lone Star Gas Company, showing hydrogen sulphide scrubbers



The Removal of Hydrogen Sulphide From Gas Containing Oxygen

Small concentration of the hydrogen sulphide, necessity for almost complete removal, and presence of carbon dioxide and oxygen were complicating factors

By T. S. BACON

Research Engineer, Lone Star Gas Company

THE general subject of the removal of hydrogen sulphide from gas has been widely and thoroughly investigated, and several proven commercial processes are available for sweetening gas. These commercial processes include the following:

1. Iron oxide (dry) process.[1, 2, †]
2. Seaboard (soda-ash solution) process.[3]
3. Thylox (sodium arsenate solution) process.[4, 5]
4. Sodium phenolate process.[6]
5. Girdler (organic amine solution) process.[7]
6. Tripotassium phosphate process.[8]

A thorough study and comparison of the above processes from the chemical, engineering, and economic viewpoints is prerequisite to selection of the best process for any given problem. The general factors that must be considered include the following:

1. Treating temperature.
2. Treating pressure.
3. Hydrogen sulphide content of raw gas.
4. Permissible hydrogen sulphide content of treated gas.
5. Volume of gas to be treated.
6. Availability and cost of utilities.
7. Gas composition.

Operating data are available pertaining to the use of most of these processes on refinery gases, natural gases, and manufactured gases, and operating results can be predicted fairly accurately for almost any given conditions. Treating conditions on one project, however, were so unusual that a novel treating process was developed to meet the treating conditions. As these conditions may be faced by other operators, the conditions and the remedy will be described.

The Lone Star Gas Company has been buying residue gas from several casinghead gasoline plants in the Breckenridge, Texas, district. This gas is compressed after purchase to a pressure of about 350 lb. per sq. in. and delivered into the main distribution lines of the company. Serious inter-

†Numbers refer to articles listed in bibliography at end of article.

T. S. BACON

began his business career with the Hercules Powder Company, Wilmington, Delaware, in 1928 as research engineer—From 1929 to 1931 was research chemist for Arab Gasoline Company, Eastland, Texas—1931 to present research engineer with Lone Star Gas Company, Dallas, Texas.

Received bachelor's degree from Swarthmore College and master's degree from Massachusetts Institute of Technology—Is member of American Chemical Society.

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nal corrosion of the main gas transmission lines was observed, although internal corrosion of the low-pressure (20 to 30 lb. per sq. in.) feeder lines from the gasoline plants was negligible. A careful analysis of the causes of corrosion made by the chemists, and confirmed and amplified by the Bureau of Mines,[9] showed that main-line corrosion was caused by the combined action of the following:

1. Liquid water.
2. Free oxygen in the gas.
3. Low concentration of hydrogen sulphide in the gas.
4. High pressure on the main transmission lines.

The Breckenridge casinghead gasoline plants obtain gas from wells operated under vacuum, and oxygen enters the gas because of unavoidable leakage of air into the vacuum gathering systems. The leakage is sufficient to maintain a concentration of 1.0 to 1.8 percent oxygen in the gas entering the compressor station. The gas is also slightly sour, containing 1.5 to 4.0 grains of hydrogen sulphide per 100 cu. ft. as received at the compressor station. The gas also contains 0.2 to 0.4 percent carbon dioxide, which prevents the economical use of a straight caustic wash for removal of the hydrogen sulphide. Corrosion tests made on samples of steel under main-line conditions indicated that the hydrogen sulphide content of the treated gas should not exceed 0.10 grains per 100 cu. ft. Gas volume varied between 10,000,000 and 15,000,000 cu. ft. per day.

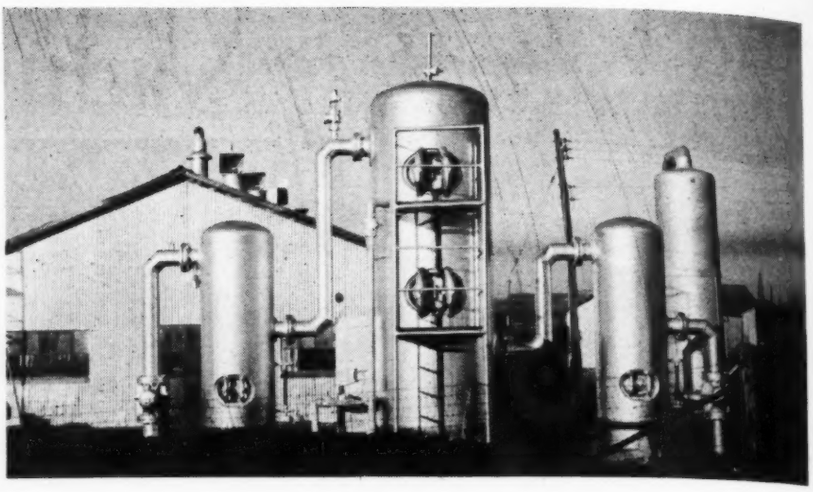
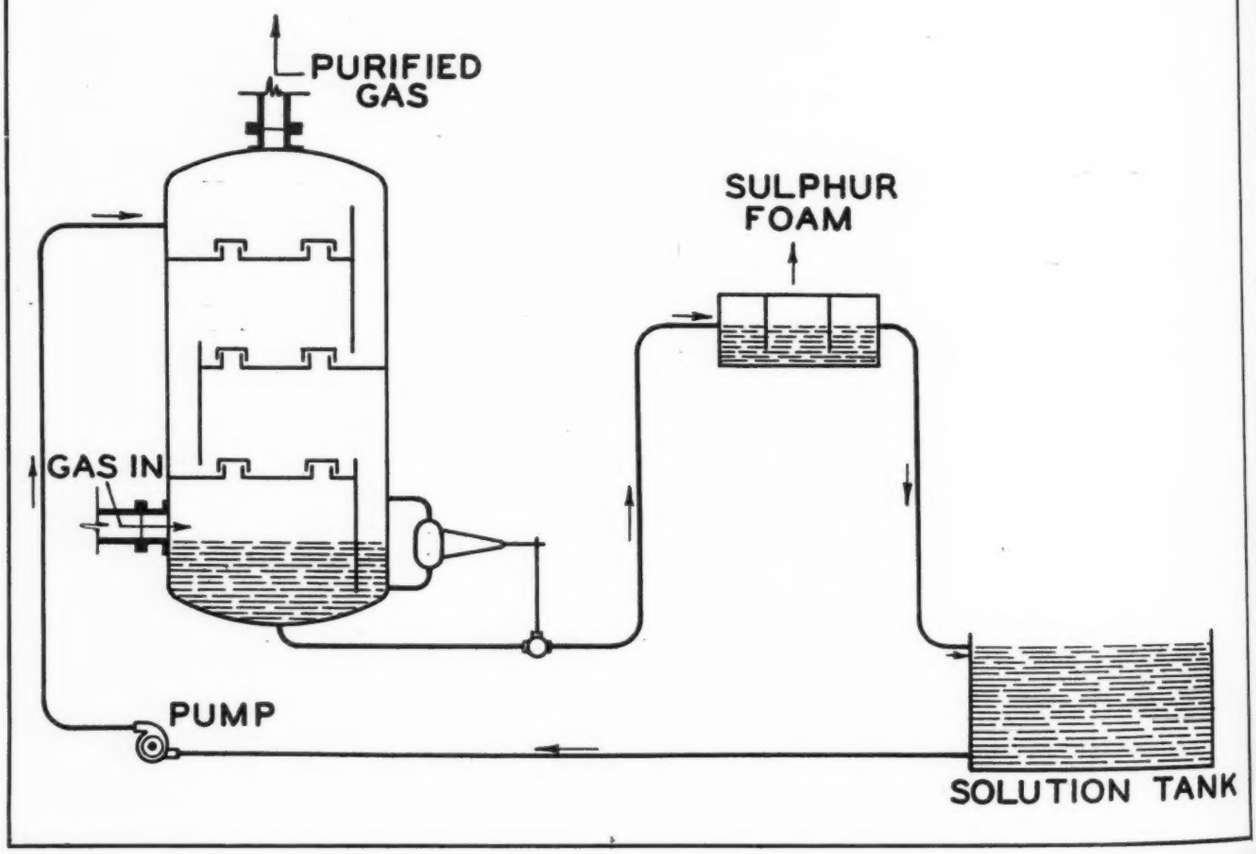


Fig. 3. High-pressure hydrogen sulphide scrubber and mist extractors

The total amount of hydrogen sul-

Fig. 2. Flow diagram of hydrogen sulphide removal plant



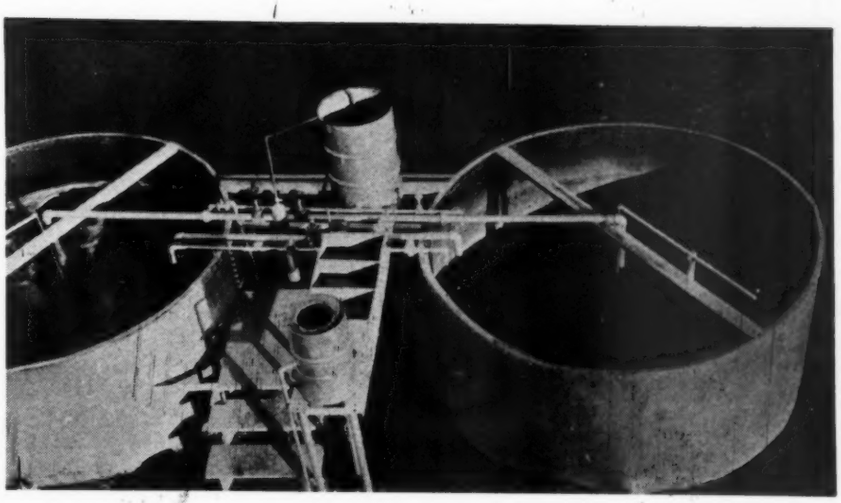


Fig. 4. Solution tanks and sulphur foam box

phide to be removed in this purification plant was extremely small, but to reduce the residue hydrogen sulphide content to the permissible maximum of 0.10 grains per 100 cu. ft. of treated gas required a plant of excellent efficiency. It seemed possible that the iron oxide process might prove to be successful in this application; however, large oxide beds would be required to insure this low final concentration of hydrogen sulphide, and pressure boxes for these beds would require a large investment.

The process as finally developed involves the absorption of hydrogen sulphide in an alkaline solution, and oxidation of the absorbed hydrogen sulphide to free sulphur.[10] The free oxygen already present in the gas is used to accomplish this oxidation. The normal rate of oxidation of hydrogen sulphide absorbed in a sodium carbonate solution that also contains dissolved oxygen is extremely slow. A catalyst, formed of iron and zinc salts, is added to the alkaline scrubbing solution to increase the rate of sulphide oxidation.

The absorption of hydrogen sulphide by a sodium carbonate solution is a reversible reaction, and hydrogen sulphide can be liberated from the fouled solution by blowing air through it, as in the Seaboard process. Liberation of hydrogen sulphide from the solution is also aided by the presence of carbon dioxide. Therefore, in this application, the ordinary solution of sodium carbonate would not purify the gas satisfactorily, owing to the small amount of hydrogen sulphide and the comparatively large amount of carbon dioxide in the gas. The sodium carbonate solution does become effective, however, after the addition of the oxidation catalyst, as the hydrogen sulphide absorbed by the solution is removed from the solution by oxidation, and therefore does not adversely affect the absorption of additional hydrogen sulphide by the solution. The partial pressure of the hydrogen sulphide in the gas above the solution is very slight at all times, owing to the rapid oxidation of the absorbed hydrogen sulphide. Therefore, the solution is capable of removing hydrogen sulphide from the gas almost quantitatively.

The complete Breckenridge treating plant is shown in Fig. 1, and the simple flow diagram of the treating process is shown in Fig. 2. Natural gas is compressed in two stages in this plant, and is treated for removal of hydrogen sulphide after each stage of compression. The intermediate pressure scrubber (left foreground) is 6 ft. in diameter, contains six trays, and operates at a pressure of approximately 100 lb. per sq. in. gauge. Gas from the compressor station intercoolers enters this scrubber through a small mist extractor (lower left), leaves the top of the scrubber, and passes to the high-stage compressor cylinders. The scrubbing solution is prepared in one of two low cylindrical tanks at the base of the intermediate pressure scrubber. The solution is pumped continuously from this tank into the top of the scrubber, and is returned to the same tank from the base of the scrubber. This circulation of solution through the scrubber is not required for gas purification, but is of practical value in removing the free sulphur from the interior of the scrubber. The sulphur present in the solution leaving the scrubber separates from the solution as a foam, owing to the action of dissolved gases liberated from the solution by reduction of pressure. The sulphur foam is readily skimmed from the solution and discarded, and hence does not plug the interior of the scrubber.

The high-pressure scrubber (right foreground of Fig. 1) operates in an identical manner, at a pressure of 300 to 375 lb. per sq. in. gauge. Large mist extractors are used on the inlet and outlet of the high-pressure scrubber, as shown in Fig. 3. The use of two independent scrubbers permits continuous purification of the gas even though one scrubber is shut-down for cleaning or repairs.

Some free sulphur is deposited on the metal surfaces in the scrubbers, and must be removed manually every 90 days. The specially designed scrubber trays and bubble-caps have flat accessible surfaces to facilitate cleaning. Stainless steel trays and caps are used, and the internal surfaces of the scrubber shells are protected from corrosion by a lining of special concrete. Plunger-type pumps equipped with stainless-steel plungers and valves are used for circulation of solution.

The scrubbing solution loses its effectiveness, owing to side reactions, and is replaced every seven days. Sodium sulphate and sodium thiosulphate are identified products of side reactions. The fresh scrubbing solution is made-up in the other solution tank shown in Fig. 1, and is put into use without any interruption to scrubber operation.

This plant has operated satisfactorily for several years, using this low-cost method for the removal of hydrogen sulphide from gas containing free oxygen.

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Energy required to lift fluid (sheet 3)	P 519.5	137	Nov.
Velocity of flow through 1¼-in. tubing	P 533.300.125	125	Sept.
Velocity of flow through 1½-in. tubing	P 533.300.15	117	Aug.
Velocity of flow through 4-in. tubing	P 533.300.4	135	June
Pressure drop per mile of 8-in. pipe line, oil of 30° A.P.I.	P 615.108.30	125	June
Pressure drop per mile of 10-in. pipe line, oil of 30° A.P.I.	P 615.110.30	109	Aug.
Temperature-specific gravity multipliers, Weymouth's formula (sheet A)	P 621.100.1	245	Oct.
Diameter-length multipliers, Weymouth's formula (sheet B)	P 621.100.1	141	Nov.
Capacity of bolted tanks (sheet 2)	P 644.200.1	113	Aug.
Capacity of bolted tanks (sheet 3)	P 644.200.1	119	Aug.
Specific gravity of sulphuric acid solutions (sheet 2)	P 725.113.2	119	Sept.
Equilibrium constants (K-values) of n-butane	P 771.214.740	81	Feb.
Equilibrium constants (K-values) of iso-butane	P 771.214.745	73	Jan.
Equilibrium constants (K-values) of n-pentane	P 771.214.750	247	Oct.
Equilibriur constants (K-values) of iso-pentane	P 771.214.755	75	Jan.

*This index of the second twelve installments is revised monthly as additional tables are published. A complete index of all tables included in the first twelve installments was published in the May issue.

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Linde Air Products Company (sheet A)	246	Oct.	P 621.100.1
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Lunkenheimer Company	74	Jan.	P 771.214.745
MacClatchie Manufacturing Co. (sheet 4)	72	Jan	P 448.430
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Merla Tool Company (sheet 2)	88	Feb.	P 515.5
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A Decimal System for Classifying Data Pertaining to the Petroleum Industry

Part 2

By

LESTER C. UREN

Professor of Petroleum Engineering, University of California, Berkeley, California

EDITOR'S NOTE: On this and following pages are presented the third and fourth divisions of the Uren Classification. The remaining six divisions will appear in later issues of *The Petroleum Engineer*. An introductory article by Professor Uren appeared in the November issue. The first two divisions of the Classification were printed in the January issue. For permission to publish this material, *The Petroleum Engineer* is indebted to the publishers of *National Petroleum News*, owners of the copyright on the 1928 edition of the Classification.

200 to 299. Physical and Chemical Properties of Petroleum; Examination, Testing, and Sampling

200. General reference, text, and hand books and general articles on physical and chemical properties, analysis, testing, and sampling. (Arranged in alphabetical sequence by initial letters of author's names.)

201. Chemical and physical periodicals and journals. (Arranged in alphabetical sequence.) (See also under 010.)

202. Chemical, physical, and testing societies, organizations, and institutions: proceedings, bulletins, transactions, and other publications.[10] (Arranged in alphabetical sequence.) (See also under 020.)

203. Chemical and physical nomenclature: definitions. (Arranged alphabetically by initial letter of words defined.) (See also under 050.)

[10]This number may also include publications of government bureaus, if desired.

L. C. UREN

is professor of petroleum engineering at the University of California. He received his Bachelor of Science degree from the College of Mining, University of California, in 1911 and has taught courses in mining and petroleum engineering there since 1912, ranking as senior professor in the petroleum division of the department of mining since the inception of the division in 1915. He has supervised the preparation of more than 100 senior and graduate theses in petroleum technology and is a member of the research committee and director of Project No. 28 of the American Petroleum Institute, and a member of the research committees of the American Association of Petroleum Geologists, of the American Institute of Mining and Metallurgical Engineers, and of the National Research Council. His teaching duties have restricted his commercial work to consultation and appraisal on behalf of several important companies and federal and local governmental agencies and as an expert witness in litigation. He is a member of the professional societies mentioned, and of Sigma Xi, Tau Beta Pi, and Theta Tau honorary fraternities. He is author of more than 100 papers on petroleum technology and of two volumes on petroleum engineering extensively used as text and reference books.

204. History, progress, and development of physics and chemistry, particularly as applied to the testing of petroleum, natural gas, and other bitumens.

205. Miscellaneous tests and analyses of petroleum, gases, and solid bitumens from particular fields or localities.[11]

206. General physical and chemical instruments and reagents.[12]

.1 Chemical reagents, solvents, and other laboratory materials.

.2 Laboratory equipment, miscellaneous.

.3 Gravimetric apparatus.

.31 Balances and weights.

.32 Hydrometers.

.33 Pycnometers and specific gravity bottles.

.4 Volumetric apparatus; calibrated vessels.

.41 Graduated cylinders, flasks, pipettes, burettes, etc.

.42 Centrifuge burettes.

.5 Gas analysis apparatus.

.51 Liquid absorption apparatus.

.52 Explosion apparatus.

[11]This number may conveniently be subdivided according to the geographic index: 110 to 190.

[12]When possible, in classifying instruments and reagents, preference will be given to numbers assigned to the physical and chemical tests and operations for which the apparatus or reagent is particularly intended. The present number is provided to include all general physical and chemical equipment that cannot be definitely allocated.

.53 Selective condensation apparatus.
.54 Gas density apparatus.
.6 Heat- and temperature-measurement apparatus.
.61 Thermometers and pyrometers.
.62 Calorimeters.
.63 Melting-point and pour-point apparatus.
.7 Electric, magnetic, and galvanic apparatus for testing.
.71 Heaters, ovens, hot-plates, etc.
.72 Galvanometers and potentiometers.
.73 Ammeters, volt-meters, and watt-meters.
.74 Conductivity and resistivity apparatus.
.75 Thermocouples.
.76 Cathode-ray equipment; oscillographs.
.77 Galvanic cells and storage batteries.
.78 Radio apparatus.
.79 Miscellaneous other electric, magnetic, and galvanic apparatus.
.8 Mechanical apparatus.
.81 Centrifuges.
.82 Filtration equipment.
.9 Other physical and chemical apparatus.
.91 Microscopic and other optical instruments and apparatus.

207. General physical and chemical tables, formulas, and constants.[13] (See also under 060.)[14]

208. Petroleum chemists, physicists, and analysts: directories and biographies. (Arranged in alphabetical sequence by initial letter of names.) (See also under 081.)

209. Miscellaneous other data on physical and chemical properties of petroleum and on testing and sampling.

210. Physical properties of petroleum, natural gas, and other bitumens and methods of determination: general data on physical properties.

[13]When possible, preference will be given to numbers assigned to physical and chemical tests to which the formulas, tables, and constants particularly apply. The present number is intended to provide for all general physical and chemical tables, formulas, and constants that cannot be allocated definitely.

[14]Mathematical tables and formulas are filed under 061.

211. Optical properties.
.1 Refractivity and refractometers.
.2 Polarization and polariscopes; rotatory power.
.3 Color and colorimetric apparatus.
.4 Transparency and turbidometers.
.5 Fluorescence (bloom).
.6 Sensitiveness to light; photo-chemical properties.
.61 Spectrograph.
.62 Stroboscope.
.63 Photometric determinations.
.7 Radioactivity.
.9 Other optical properties.

212. Odor.

213. Density and volume relationships; apparatus for determining density, volume, and compressibility.
.1 Density relationships.
.11 Baumé scales.
.12 Density determination apparatus.
.121 Hydrometers.
.122 Westphal balances.
.123 Specific gravity apparatus.
.2 Coefficient of expansion: theory, methods of determining, and experimental values.
.3 Compressibility: theory, methods of determining, and experimental values.

214. Changing phase properties: theories, methods of measurement, instruments, and experimental values.
.1 Boiling point.
.2 Evaporation and volatility.
.21 Vapor pressure apparatus and tests.
.22 Latent heat of vaporization apparatus and tests.
.23 Vapor density apparatus and tests.
.3 Fractional distillation.
.31 Distillation apparatus and tests.
.4 Melting point.
.5 Congealing point and cold tests.
.6 Crystallization.

215. Other properties of gases; theories; methods of measurement, instruments, and experimental values.
.1 Diffusion of gases.
.2 Absorption and adsorption of gases.
.3 Solubility of gas in petroleum and related substances.

216. Other properties of liquids: theories; measurement of; instruments, and experimental values.
.1 Viscosity and fluidity.
.11 Definitions and physical significance.
.111 Absolute viscosity.
.112 Influence of temperature on viscosity.
.12 Viscosimeters.
.13 Viscosity conversion tables and charts. (See also under 207.)
.2 Surface tension, capillary and diffusion phenomena.
.3 Filtration.
.4 Solubility and fractional precipitation.
.5 Emulsibility.
.6 Absorption.

217. Other properties of solids and semi-solids: theories, methods of measurement, instruments, and experimental values.
.1 Hardness; penetrometry.
.2 Ductility.
.3 Toughness and cohesion; strength.
.4 Adhesion.
.5 Consistency and viscosity of semi-solids.
.6 Solubility.

219. Other physical tests.
.1 Sizing tests of sands.
.2 Microscopic examination.
.3 Corrosion and gumming tests.
.4 Porosity tests.
.5 Permeability tests.

220. Chemical properties of petroleum, natural gas, and other bitumens, and methods of determination: general data on chemical properties.

221. Elements present in petroleum, natural gas, and other bitumens; methods of making ultimate (elementary) analyses.[15]

[15]Numbers under 221 may be subdivided merely into: .1 Gases; .2 Liquids; and .3 Solids.

.1 Carbon in petroleum and related substances.

.2 Hydrogen in petroleum and related substances.

.3 Nitrogen in petroleum and related substances.

.4 Oxygen in petroleum and related substances.

.5 Sulphur in petroleum and related substances.

.6 Halogens in petroleum and related substances.

222. Molecular weights and ionic relationships.

.1 Cracking of petroleum and related substances.

.2 Polymerization of petroleum and related substances.

223. Hydrocarbon compounds and derivatives in petroleum, natural gas, and other bitumens: their identification, synthesis, and reactions with various substances.

.01 Liquid petroleums.

.02 Natural gases.

.03 Asphalts.

.04 Mineral waxes.

.05 Oil shales.

.1 Paraffins.

.2 Olefines and polymethylenes (naphthenes).

.3 Acetylenes.

.4 Turpenes.

.5 Benzenes.

.6 Oxygen compounds and oxidation; action of acids in and on petroleum.

.61 Organic acids in petroleum.

.62 Carbon dioxide in petroleum and related substances.

.63 Oxygenated hydrocarbons: asphalts and tarry substances.

.7 Halogen compounds in petroleum.

.8 Hydrogenation and catalysis.

.9 Other compounds and derivatives.

.91 Nitrogen compounds and derivatives in petroleum.

.92 Sulphur compounds and derivatives in petroleum.

224. Analytical numbers; reactions and standard solutions: methods of determining, and experimental values.

225. Determination of water, solids, and other impurities in liquid hydrocarbons.

.1 Determination of water and suspended solids.

.11 Centrifuge method.

.12 Distillation methods.

.13 Electrical method.

.14 Calcium carbide method.

.2 Determination of sulphur in petroleum.

.3 Determination of nitrogen in petroleum.

.4 Determination of acids in petroleum.

.5 Determination of ash content of petroleum and related hydrocarbons.

226. Determination of impurities in asphalts, waxes, and shales.

227. Estimation of vaporized constituents, foreign gases, and other impurities in natural gases.

.1 Water vapor in natural gas.

.2 Condensable hydrocarbon vapors in natural gas.

.21 Oil absorption method.

.22 Charcoal adsorption method.

.23 Selective condensation method.

.3 Sulphur compounds in natural gas.

.4 Carbon dioxide and oxygen in natural gas.

.5 Nitrogen in natural gas.

.6 Helium in natural gas.

228. Determination of mixtures and adulterants.

.1 Estimation of petroleum derivatives as adulterants.

.2 Estimation of foreign adulterants in petroleum products.

229. Miscellaneous other tests and methods.

230. Thermal properties of petroleum, natural gas, and other bitumens, and methods of determination; general data on thermal properties.

231. Ignition variables: flash points and burning points; ignition points and explosive mixtures; theory, methods, and instruments; experimental data.

.1 Instruments: flash testers.

.2 Flash point: physical significance and experimental values.

.3 Burning point: physical significance and experimental values.

.4 Explosive mixtures: percentage of air and various gases forming explosive mixtures; theory, and experimental values.

232. Combustion, calorific power, and calorimetry; theory, methods, and instruments; experimental data.

.1 Theory of combustion.

.2 Calorimeters for liquids and solids.

.3 Calorimeters for gases.

233. Illuminating power, burning qualities, and photometry; theory, methods, and instruments; experimental data.

.1 Burning qualities of oils and methods of testing lamps and wicks; burners.

.2 Illuminating power and methods of measurement: photometers.

234. Thermal decomposition or "cracking" (pyrolysis).

.1 Theory of cracking: chemistry of the process.

.2 Physical conditions influencing thermal decomposition.

.3 Cracking stills and accessories (experimental).

.4 Catalysts, use of in cracking (experimental).

235. Specific heats: theory, methods, and instruments for determining; experimental data.

236. Carbonization.

.1 Low-temperature carbonization (experimental).

.2 Franz Fisher and Bergius methods (experimental).

.3 Conradson carbon residue apparatus.

.4 U. S. Bureau of Mines method.

237. Heat values incidental to physical and chemical changes.

.1 Heats of reaction and formation.

.2 Heat of fusion.

.3 Free energy and entropy.

.4 Heat of adsorption and absorption.

238. Heat absorption, conduction, and radiation constants.
.1 Specific heats of petroleum and other bituminous substances.
239. Other thermal properties.
240. Medicinal and physiological properties.
241. Asphyxiating properties.
242. Toxic properties.
243. Anaesthetizing properties.
244. Laxative effects (mechanical).
245. Emollients.
249. Other medicinal and physiological properties.
250. Power and thermal efficiency tests.
251. Steam boiler tests.
252. Internal combustion engine tests.
253. Industrial furnace tests.
254. Domestic appliance tests.
255. Petroleum versus coal as a fuel (in general).
256. Natural gas versus other fuels (in general).
259. Other thermal efficiency tests.
260. Tests of various species and fractions of petroleum and bitumen.
261. Crude oils.
262. Gaseous products, including natural gas.
263. Volatile fractions, including naphthas, gasoline, and benzine.
.1 Motor fuels.
.2 Natural gasoline (casinghead gasoline).
.3 Solvent naphthas.
.4 Liquid butane and propane.
264. Illuminating and gas oils.
.1 Kerosene.
.2 Mineral seal oil.
265. Lubricating, transformer, and switch oils; absorption oils.
266. Residuum and fuel oils; Diesel fuel oils.
267. Paraffin waxes, including ozokerite, vaseline, ceresin, etc.
268. Asphalts, tars, road oils, etc.
269. Oil shales, miscellaneous solid bitumens, lamp black, coke, etc.
.1 Oil shales.
.2 Petroleum coke.
.3 Lamp black.
.4 Coal, peat, and lignite.
.5 Charcoal.
270. Specifications for purchase of various species and fractions of petroleum and other bitumens.[16]
.1 Standardization of petroleum and bituminous products.
280. Sampling liquid, gaseous, and solid hydrocarbons.
281. Sampling of gases. (See also under 688.)
282. Sampling of liquids (See also under 676 and 747.)
.1 Sampling instruments: oil thiefs.
.11 Bottom-closure types.
.12 Bottle types.
.13 Core types.
.2 Mechanical sampling devices.
283. Sampling of solids. (See also under 478.)
290. Miscellaneous other data on properties of bitumens, examination, testing, and sampling.

300 to 399. Exploration and Prospecting for Petroleum and Other Bitumens; Geology of Petroleum

300. General geological reference, text, and hand books on petroleum, geology, and exploration. (Arranged in alphabetical sequence.)
301. Geological periodicals and journals. (See also under 025.) (Arranged in alphabetical sequence.)
302. Geological societies, organizations, and institutions: proceedings and publications. (Arranged in alphabetical sequence according to initial letter of name of society.)
303. Geological nomenclature: definitions. (Arranged in alphabetical sequence.)
304. History, progress, and development of petroleum geology as a science.
305. General geological descriptions and maps of oil fields and districts.[17] (See also under 100-190.)
306. Geological and exploration outfits and equipment; testing devices and instruments.
.1 Field equipment.
.11 Conveyances and transportation equipment.
.12 Surveying instruments.
.13 Aerial mapping equipment.
.14 Equipment for structure drilling.
.2 Laboratory equipment.
.21 Petrographic equipment.
.211 Petrographic and binocular microscopes.
.212 Sizing equipment; laboratory screens and elutriators.
.213 Equipment for porosity determination.
.214 Equipment for permeability determination.
.215 Equipment for heavy mineral segregation.
.216 Soil analysis equipment.
.22 Paleontologic equipment.
.3 Geophysical equipment.
.31 Torsion balances and related equipment.
.32 Seismographs, sonographs, geophones, and related equipment.
.33 Pendulums and gravitometers and related equipment.
.34 Magnetometers and related equipment.
.35 Electrical equipment for geophysical exploration.
.351 Resistivity apparatus.
.352 Variometers.
.36 Thermometric equipment.
.39 Other geophysical equipment.
.391 "Doodlebugs".
.4 Office equipment.
.41 Drafting equipment.
.42 Photographic equipment.
.421 The photostat.
.43 Stereoscopes.

[16] Subdivisions under 271 to 279 are identical with those under 261 to 269.

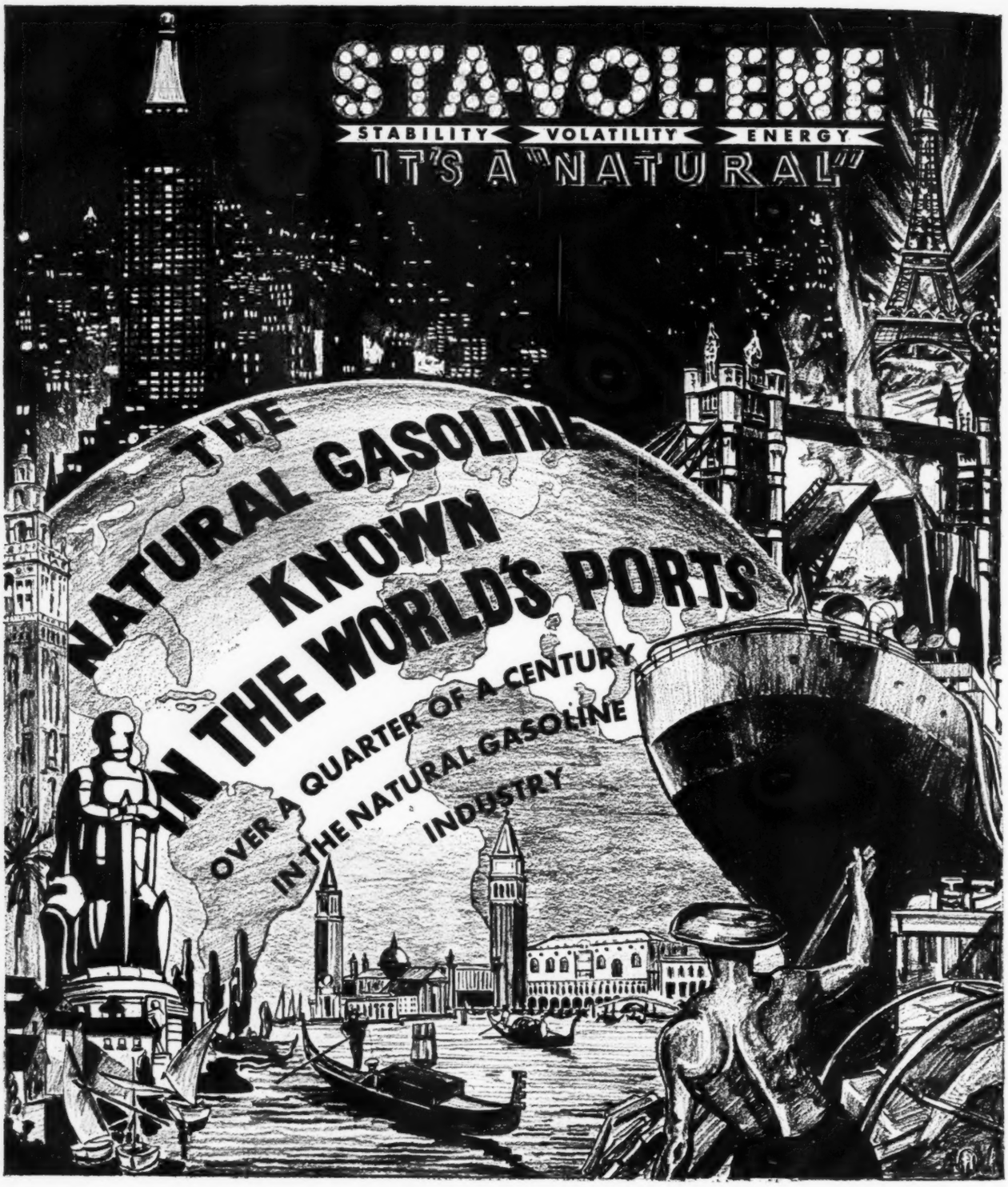
[17] This number may be subdivided according to the geographical index: see 100-190.

(Continued on Page 83)

VAPORIZATION EQUILIBRIUM CONSTANTS[1] (K-VALUES) OF n-BUTANE

Temperature, deg. fahr.	Pressure, lb. per sq. in. abs.																			
	10	14.7	20	30	40	50	60	70	80	90	100	120	140	160	180	200	250	300	400	500
0	.70	.49	.37	.27	.21	.166	.144	.127	.116	.107	.097	.085	.074	.069	.063	.059	.052	.047	.041	.037
20	1.12	.79	.58	.41	.32	.26	.226	.197	.179	.163	.148	.129	.116	.106	.096	.089	.078	.071	.062	.056
40	1.69	1.18	.88	.62	.47	.38	.33	.288	.260	.237	.217	.187	.168	.154	.140	.131	.114	.103	.090	.082
60	2.43	1.71	1.28	.89	.68	.55	.47	.41	.37	.33	.31	.264	.234	.215	.198	.186	.163	.147	.127	.117
80	3.4	2.4	1.79	1.23	.94	.76	.64	.56	.50	.45	.42	.36	.32	.29	.275	.255	.224	.202	.175	.159
100	4.7	3.2	2.43	1.67	1.27	1.03	.87	.76	.68	.61	.56	.48	.43	.39	.37	.34	.30	.27	.236	.213
120	6.2	4.3	3.26	2.21	1.68	1.36	1.14	.99	.90	.80	.73	.63	.56	.51	.47	.44	.39	.35	.304	.274
140	8.1	5.5	4.2	2.83	2.16	1.74	1.46	1.27	1.14	1.02	.93	.80	.72	.64	.60	.56	.48	.44	.385	.347
160	10.2	7.0	5.3	3.6	2.7	2.18	1.82	1.58	1.42	1.27	1.16	.99	.88	.80	.75	.70	.60	.54	.47	.43
180	12.6	8.6	6.5	4.4	3.3	2.67	2.23	1.93	1.72	1.53	1.40	1.21	1.07	.97	.90	.84	.72	.65	.56	.51
200	15.0	10.3	7.8	5.2	3.9	3.2	2.65	2.30	2.06	1.82	1.67	1.43	1.29	1.16	1.07	.99	.85	.77	.66	.59
220	17.6	12.1	9.2	6.1	4.6	3.7	3.1	2.70	2.39	2.13	1.94	1.68	1.50	1.33	1.22	1.13	.98	.88	.75	.68
240	20	13.8	10.3	6.9	5.3	4.2	3.5	3.1	2.7	2.42	2.23	1.90	1.68	1.51	1.39	1.26	1.10	.99	.84	.76
260	22	15.3	11.2	7.7	5.9	4.7	4.0	3.4	3.0	2.7	2.46	2.12	1.86	1.67	1.52	1.40	1.22	1.09	.93	.84
280	24	16.8	12.1	8.4	6.5	5.2	4.4	3.8	3.3	3.0	2.7	2.3	2.04	1.82	1.67	1.53	1.33	1.18	1.02	.92
300	26	18.0	13.0	9.0	7.0	5.7	4.8	4.1	3.6	3.2	2.9	2.5	2.20	1.97	1.81	1.66	1.43	1.27	1.10	1.00
320	28	19.4	14.1	9.7	7.5	6.1	5.1	4.4	3.9	3.5	3.1	2.7	2.36	2.10	1.93	1.78	1.53	1.36	1.19	1.08
340	30	21	15.2	10.5	8.0	6.5	5.5	4.7	4.1	3.8	3.3	2.9	2.5	2.25	2.08	1.90	1.63	1.45	1.27	1.16
360	32	22	16.3	11.2	8.6	7.0	5.9	5.0	4.4	4.0	3.6	3.1	2.7	2.40	2.20	2.02	1.74	1.55	1.36	1.24
380	34	24	17.6	12.0	9.2	7.5	6.3	5.4	4.7	4.3	3.8	3.3	2.9	2.55	2.35	2.16	1.85	1.64	1.45	1.33
400	36	25	18.7	12.8	9.8	8.0	6.7	5.7	5.0	4.5	4.1	3.5	3.1	2.7	2.50	2.30	1.97	1.73	1.54	1.42
420	38	27	19.8	13.5	10.3	8.5	7.1	6.0	5.3	4.8	4.3	3.7	3.2	2.9	2.65	2.43	2.08	1.83	1.63	1.51
440	41	28	21.0	14.2	10.9	8.9	7.5	6.4	5.6	5.1	4.5	3.9	3.4	3.1	2.8	2.56	2.20	1.94	1.73	1.60
460	43	30	22.2	15.1	11.6	9.4	7.9	6.7	5.9	5.4	4.8	4.1	3.6	3.3	3.0	2.7	2.34	2.06	1.83	1.70
480	46	32	23.6	16.0	12.3	9.9	8.4	7.1	6.2	5.7	5.1	4.3	3.8	3.5	3.2	2.9	2.48	2.18	1.94	1.80
500	49	34	25.0	17.1	13.0	10.4	8.9	7.6	6.6	6.0	5.4	4.6	4.1	3.7	3.4	3.1	2.61	2.31	2.05	1.90
520	52	36	26.4	18.1	13.8	11.2	9.5	8.1	7.0	6.4	5.8	4.9	4.3	3.9	3.6	3.3	2.76	2.44	2.17	2.02
540	55	38	28	19.1	14.6	12.0	10.0	8.6	7.5	6.8	6.1	5.2	4.6	4.1	3.8	3.5	2.93	2.60	2.30	2.14
560	58	40	30	20.3	15.5	12.7	10.6	9.1	7.9	7.2	6.5	5.5	4.9	4.3	4.0	3.7	3.12	2.75	2.45	2.27
580	62	42	32	21.6	16.5	13.4	11.3	9.6	8.4	7.7	6.9	5.8	5.2	4.6	4.2	3.9	3.3	2.9	2.60	2.41
600	66	45	34	22.9	17.4	14.2	12.0	10.2	8.9	8.1	7.3	6.2	5.5	4.9	4.5	4.1	3.5	3.1	2.75	2.56
620	70	48	36	24.2	18.5	15.1	12.7	10.8	9.5	8.6	7.8	6.6	5.8	5.2	4.8	4.4	3.7	3.3	2.9	2.7
640	74	51	38	25.7	19.7	16.0	13.4	11.5	10.0	9.1	8.3	7.0	6.2	5.5	5.1	4.7	3.9	3.5	3.1	2.9
660	78	54	40	27.3	20.9	17.0	14.2	12.2	10.6	9.7	8.8	7.4	6.6	5.8	5.4	5.0	4.2	3.7	3.3	3.1
680	83	57	42	29	22.3	18.1	15.1	12.9	11.3	10.3	9.3	7.9	7.0	6.2	5.7	5.3	4.5	3.9	3.5	3.3
700	88	60	45	31	23.7	19.2	16.1	13.7	12.0	11.0	9.8	8.4	7.5	6.6	6.1	5.6	4.8	4.1	3.7	3.5
720	94	64	48	33	25.0	20.3	17.1	14.5	12.8	11.6	10.3	8.9	8.0	7.0	6.5	5.9	5.1	4.4	3.9	3.7
740	99	68	51	35	26.3	21.6	18.1	15.4	13.6	12.3	11.0	9.4	8.5	7.5	6.9	6.3	5.3	4.7	4.1	3.9
760	.....	73	54	37	27.7	23.3	19.2	16.3	14.4	13.1	11.8	10.0	9.0	8.0	7.4	6.7	5.6	5.0	4.4	4.1
780	.....	78	58	39	30.0	25.0	20.4	17.3	15.3	14.0	12.6	10.6	9.5	8.5	7.9	7.1	6.0	5.3	4.7	4.3

[1]From curve showing equilibrium constants for n-Butane prepared by George Granger Brown, Ann Arbor, Michigan, by permission.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307. Geological and mineralogical tables, charts, and formulas.

308. Petroleum geologists: directory and biographies. (Arranged in alphabetical sequence by initial letter of names.) (See also under 080.)

309. Miscellaneous unclassified data on petroleum geology.
- .1 Field of the petroleum geologist in exploration and development.
- .2 Field of the geophysicist in exploration and development.

310. Origin and genesis of petroleum: geochemistry.

311. Organic theories of petroleum origin.

312. Inorganic theories of petroleum origin.

313. Carbon ratios and their significance.

314. Synthetic methods for artificial production of petroleum.

315. Role of natural associations in genesis of petroleum and in influencing its physical properties and chemical constitution.
- .1 Role of bacteria in formation of petroleum.
- .2 Influence of sulphur compounds on properties of petroleum.
- .3 Influence of saline ground waters.
- .4 Filtrative effects of clays.
- .5 Metamorphic influences: effects of earth pressure and temperature.

319. Other factors bearing on petroleum genesis.
- .1 Radioactivity of petroleum.
- .2 Optical properties of petroleum.

320. Stratigraphic distribution of petroleum: paleontological applications.

321. Petroliferous horizons: geologic age of formations producing petroleum.

322. Types of fossils characterizing different geologic periods; paleontology of petroliferous formations.
- .1 Flora.
- .2 Fauna.

323. Application of paleontological methods to stratigraphic correlations in areal studies.
- .1 Micropaleontology.

329. Other matters pertaining to stratigraphic distribution of petroleum.

330. Economic geology of petroleum. Types of deposits. Structural features and factors influencing migration and accumulation.

331. Forces causing movement of oil through rocks.
- .1 Diastrophism as cause of oil migration.
- .2 Hydraulic pressure.
- .3 Selective action of gravity: the anticlinal theory.
- .4 Influence of moving gas on oil migration.
- .5 Capillarity and its influence on oil migration.
- .6 Compaction and consolidation of sediments.

332. Essential conditions for accumulation of petroleum.
- .1 Source sediments.
- .2 Carrier beds.
- .3 Reservoir rocks.
- .4 Cap rocks.
- .5 Shore-line conditions of deposition of sediments.

333. Types of petroleum and natural gas deposits; structural features influencing oil and gas accumulations.
- .1 Anticlines.
- .2 Domes.
- .3 Monoclines and terraces.
- .4 Accumulations against unconformities.
- .5 Faults and their influence on oil accumulation.
- .6 Lenticular deposits.
- .7 Salt domes.
- .8 Accumulations against volcanic intrusions.
- .9 Other types of deposits.

334. Types of oil shale deposits.

335. Types of asphalt deposits.

336. Types of mineral wax deposits.

339. Other matters pertaining to migration and accumulation of petroleum and other bitumens.

340. Lithology and petrology of bituminous rocks and associated rocks.

341. Lithologic characteristics of rocks in general: methods of measuring and comparing.
- .1 Mineral content.
- .2 Porosity and form of pore spaces.
- .3 Permeability.
- .4 Size of mineral grains.
- .5 Elastic properties.
- .6 Density.
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342. Properties of hydrocarbons as mineral substances.
- .1 Liquid petroleums.
- .2 Natural gases.
- .3 Asphalts.
- .4 Mineral waxes.
- .5 Oxygenated hydrocarbons.
- .6 Oil sales.
- .61 Kerogen in oil shale.
- .9 Other naturally occurring hydrocarbons.

343. Oil reservoir rocks and associated rocks: type and characteristics.
- .1 Sands and sandstones.
- .2 Limestones and dolomites.
- .3 Conglomerates.
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344. Cap rocks.
- .1 Shales and clays.
- .2 Limestones, dolomites, and marls.
- .3 Slates.

345. Source rocks.

349. Other lithologic characteristics of bituminous rocks and associated rocks.

350. Indications of petroleum and other bitumens: associations of petroleum and natural gas in nature; surface and sub-surface signs.

351. Geological indications of petroleum and natural gas.
- .1 Structural indications. (See also under 333.)
- .2 Stratigraphic indications.
- .3 Lithologic indications.
- .4 Paleontologic indications.
- .5 Geophysical indications.
- .6 Geologic age of oil- and gas-bearing formations.

352. Surface indications of petroleum and natural gas.
- .1 Oil seepages.
- .2 Gas emanations.

.21 Mud volcanoes and mud dykes.
.3 Mineral wax.
.4 Bituminous outcrops.
.41 "Burnt shales."
.5 Saline ground waters.
.6 Sulphur and sulphur gases.
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353. Sub-surface indications of petroleum and natural gas: indications in a bore-hole. Underground conditions in oil fields.
.1 Oil- and gas-bearing strata.
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.111 By means of ether, chloroform, and other petroleum solvents and reagents applied to formation samples.
.112 By electrical resistivity methods.
.113 By devices for sampling formation fluids.
.2 Characteristics of ground waters and their relation to oil and gas accumulations.
.3 Geothermal gradients in oil fields.
.4 Sulphur compounds and their relation to petroleum deposits.

354. Characteristics of oil shale deposits.
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.2 Oil yield of shales.
.3 Petrographic characteristics.

355. Characteristics of asphalt deposits.

356. Characteristics of mineral wax deposits.

359. Other indications and associations of petroleum and related bitumens.

360. Geological surveys: practical field methods of collecting and studying data.

361. Geologic maps and sections, interpretation and use of; tectonic geology; graphic studies.

362. Topographic mapping.

363. Geologic mapping; areal and regional studies; methods of collecting field data.

364. Structural studies. (See also under 330.)

365. Lithologic studies. (See also under 340.)

366. Paleontological and stratigraphic studies: determination of geologic age of formations. (See also under 320.)

367. Interpretation and correlation of well logs and records, including peg models.
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.21 Use of micro-fossils in correlation studies.
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.42 Magnetic mineral segregation methods.

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.11 Torsion balance methods.
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.4 Electrical methods.
.41 Resistivity methods.
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.5 Thermometric methods.
.6 Chemical analysis methods.
.9 Other geophysical methods.

369. Other matters relating to the conduct of geological and geophysical surveys.

370. Selecting test well sites.

371. Geologic factors. (Subdivide as under 351.)

372. Accessibility, facilities for transportation of equipment, power development, etc.
.1 Water transport.
.2 Rail transport.
.3 Highway transport, road building.
.31 By motor truck.
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.5 Power development in areas under exploration.
.51 Steam power.
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373. Selecting test well sites with respect to property boundaries.

379. Other factors influencing selection of well sites.

380. Acquisition of lands, leases, and permits: legal restrictions.

381. Land surveys. (Subdivide according to geographic index; see under 100.)
.1 U. S. mineral land surveys, regulations governing.

382. Acquisition of property in fee.

383. Leasing land from private owners. (For laws governing private leasing, see under 984.32.)
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.11 Community leases.
.2 Leasing agreement forms.
.3 Royalties and rentals.
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384. Acquisition of land and privileges on the public domain: mineral land laws. (Subdivide according to geographical index: see under 100.)
.11 U. S. Mineral Land Laws.
.111 The Placer Law of 1872.
.112 The Mineral Land Leasing Law of 1920. (See under 984.2.)

385. Prospecting permits and agreements. (Subdivide as under 384.)

386. Land scouts: their methods and activities.

389. Other data on land acquisition.

390. Miscellaneous other data on exploration, prospecting, and geology of petroleum.

TOTAL[1] UPWARD PRESSURE AT WELL HEAD BETWEEN TUBING AND CASING, LB.

Casing diam., O.D., in.	Tubing diam., O.D., in.	Well head pressure, lb. per sq. in. gauge																	
		1000	2000	3000	3500	4000	4500	5000	5500	6000	6250	6500	6750	7000	7200	7400	7600	7800	8000
10	1¼	67,000	134,000	201,010	234,510	268,010	301,510	335,010	368,510	402,010	418,760	435,510	452,260	469,010	482,410	495,810	509,220	522,620	536,020
	1½	66,320	132,640	198,970	232,130	265,290	298,450	331,610	364,770	397,930	414,510	431,090	447,670	464,250	477,520	490,780	504,050	517,310	530,580
	2	64,730	129,460	194,200	226,560	258,930	291,290	323,660	356,030	388,390	404,580	420,760	436,940	453,120	466,070	479,020	491,960	504,910	517,860
	2½	62,670	125,340	188,020	219,350	250,690	282,020	313,360	344,700	376,030	391,700	407,370	423,040	438,700	451,240	463,770	476,310	488,840	501,380
	3	59,540	119,080	178,630	208,400	238,170	267,940	297,710	327,480	357,250	372,140	387,020	401,910	416,790	428,700	440,610	452,520	464,430	476,340
	3½	56,590	113,180	169,780	198,070	226,370	254,660	282,960	311,260	339,550	353,700	367,850	382,000	396,140	407,460	418,780	430,100	441,420	452,740
	4	53,260	106,520	159,790	186,420	213,050	239,680	266,310	292,940	319,570	332,890	346,200	359,520	372,830	383,490	394,140	404,790	415,440	426,100
10¾	1¼	77,170	154,330	231,500	270,080	308,670	347,250	385,840	424,420	463,000	482,290	501,590	520,880	540,170	555,600	571,040	586,470	601,900	617,340
	1½	76,490	152,970	229,460	267,700	305,950	344,190	382,440	420,680	458,920	478,040	497,170	516,290	535,410	550,710	566,000	581,300	596,600	611,900
	2	74,900	149,790	224,690	262,140	299,590	337,040	374,480	411,930	449,380	468,110	486,830	505,550	524,280	539,260	554,240	569,220	584,200	599,180
	2½	72,840	145,670	218,510	254,930	291,350	327,770	364,180	400,600	437,020	455,230	473,440	491,650	509,860	524,430	538,990	553,560	568,130	582,700
	3	69,710	139,410	209,120	243,970	278,830	313,680	348,540	383,390	418,240	435,670	453,100	470,520	487,950	501,890	515,830	529,770	543,710	557,660
	3½	66,760	133,510	200,270	233,650	267,030	300,410	333,780	367,160	400,540	417,230	433,920	450,610	467,300	480,650	494,000	507,350	520,700	534,060
	4	63,430	126,850	190,280	221,990	253,710	285,420	317,140	348,850	380,560	396,420	412,280	428,130	443,990	456,670	469,360	482,050	494,730	507,420
11¾	1¼	92,870	185,750	278,620	325,060	371,490	417,930	464,360	510,800	557,240	580,460	603,670	626,890	650,110	668,690	687,260	705,830	724,410	742,980
	1½	92,190	184,390	276,580	322,680	368,770	414,870	460,960	507,060	553,160	576,210	599,250	622,300	645,350	663,790	682,230	700,670	719,110	737,540
	2	90,600	181,210	271,810	317,110	362,410	407,710	453,020	498,320	543,620	566,270	588,920	611,570	634,220	652,340	670,460	688,580	706,700	724,820
	2½	88,540	177,090	265,630	309,900	354,170	398,440	442,720	486,990	531,260	553,390	575,530	597,670	619,800	637,510	655,220	672,930	690,640	708,340
	3	85,410	170,830	256,240	298,950	341,650	384,360	427,060	469,770	512,480	533,830	555,180	576,540	597,890	614,970	632,060	649,140	666,220	683,300
	3½	82,460	164,930	247,390	288,620	329,850	371,080	412,320	453,550	494,780	515,390	536,010	556,630	577,240	593,730	610,230	626,720	643,210	659,700
	4	79,130	158,270	237,400	276,970	316,530	356,100	395,660	435,230	474,800	494,580	514,360	534,150	553,930	569,760	585,580	601,410	617,240	633,060
12	1¼	99,620	199,250	298,870	348,680	398,500	448,310	498,120	547,930	597,740	622,650	647,560	672,460	697,370	717,290	737,220	757,140	777,070	796,990
	1½	98,940	197,890	296,830	346,300	395,780	445,250	494,720	544,190	593,660	618,400	643,140	667,870	692,610	712,400	732,190	751,970	771,760	791,550
	2	97,350	194,710	292,060	340,740	389,420	438,090	486,770	535,450	584,120	608,460	632,800	657,140	681,480	700,950	720,420	739,890	759,360	778,830
	2½	95,290	190,590	285,880	333,530	381,180	428,820	476,470	524,120	571,760	595,590	619,410	643,230	667,060	686,120	705,180	724,230	743,290	762,350
	3	92,160	184,330	276,490	322,570	368,660	414,740	460,820	506,900	552,980	576,020	599,070	622,110	645,150	663,580	682,010	700,450	718,880	737,310
	3½	89,210	178,430	267,640	312,250	356,860	401,460	446,070	490,680	535,280	557,590	579,890	602,190	624,500	642,340	660,180	678,030	695,870	713,710
	4	85,880	171,770	257,650	300,590	343,540	386,480	429,420	472,360	515,300	536,780	558,250	579,720	601,190	618,360	635,540	652,720	669,900	687,070
13	1¼	119,340	238,690	358,030	417,700	477,380	537,050	596,720	656,390	716,060	745,900	775,740	805,570	835,410	859,280	883,150	907,010	930,880	954,750
	1½	118,660	237,330	355,990	415,320	474,660	533,990	593,320	652,650	711,980	741,650	771,320	800,980	830,650	854,380	878,110	901,850	925,580	949,310
	2	117,070	234,150	351,220	409,760	468,300	526,830	585,370	643,910	702,440	731,710	760,980	790,250	819,520	842,930	866,350	889,760	913,180	936,590
	2½	115,010	230,030	345,040	402,550	460,060	517,560	575,070	632,580	690,080	718,840	747,590	776,340	805,100	828,100	851,100	874,110	897,110	920,110
	3	111,880	223,770	335,650	391,590	447,540	503,480	559,420	615,360	671,300	699,280	727,250	755,220	783,190	805,560	827,940	850,320	872,700	895,070
	3½	108,930	217,870	326,800	381,270	435,740	490,200	544,670	599,140	653,600	680,840	708,070	735,300	762,540	784,320	806,110	827,900	849,690	871,470
	4	105,600	211,210	316,810	369,610	422,420	475,220	528,020	580,820	633,620	660,020	686,430	712,830	739,230	760,350	781,470	802,590	823,710	844,830
13⅜	1¼	124,820	249,630	374,450	436,860	499,270	561,680	624,080	686,490	748,900	780,110	811,310	842,510	873,720	898,680	923,650	948,610	973,570	998,540
	1½	124,140	248,270	372,410	434,480	496,550	558,620	620,680	682,750	744,820	775,860	806,890	837,920	868,960	893,790	918,610	943,440	968,270	993,100
	2	122,550	245,090	367,640	428,910	490,190	551,460	612,740	674,010	735,280	765,920	796,560	827,190	857,830	882,340	906,850	931,360	955,870	980,380
	2½	120,490	240,970	361,460	421,700	481,950	542,190	602,440	662,680	722,920	753,040	783,170	813,290	843,410	867,510	891,600	915,700	939,800	963,900
	3	117,360	234,710	352,070	410,750	469,430	528,110	586,780	645,460	704,140	733,480	762,820	792,160	821,500	844,970	868,440	891,910	915,380	938,860
	3½	114,410	228,810	343,220	400,420	457,630	514,830	572,040	629,240	686,440	715,040	743,650	772,250	800,850	823,730	846,610	869,490	892,370	915,260
	4	111,080	222,150	333,230	388,770	444,310	499,850	555,380	610,920	666,460	694,230	722,000	749,770	777,540	799,750	821,970	844,190	866,400	888,620

The fact that total well head pressure for unit pressures as high as 8000 lb. per sq. in. are included in the table should not be interpreted as indicating that the casing will have sufficient bursting strength to withstand such pressure. For bursting strength of casing see Table P432.2, p. 257, August, 1937, Issue.

[1]Total for lightest weight casing, hence a maximum for each size casing.

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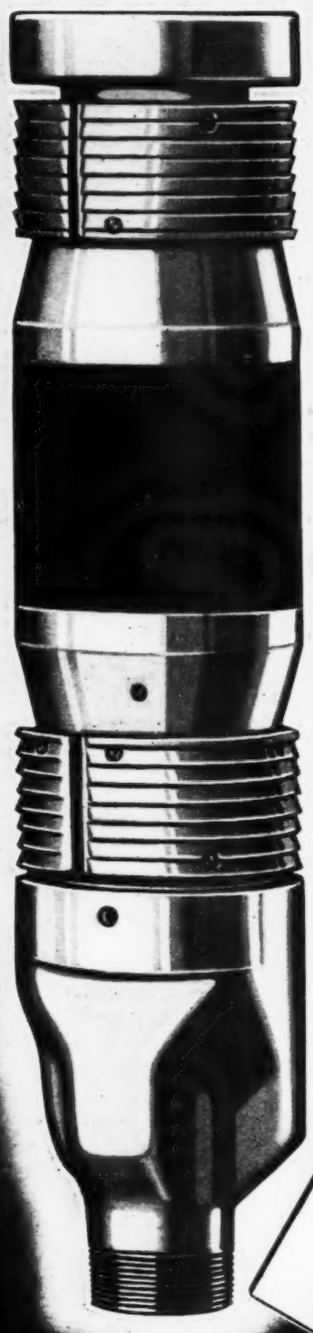

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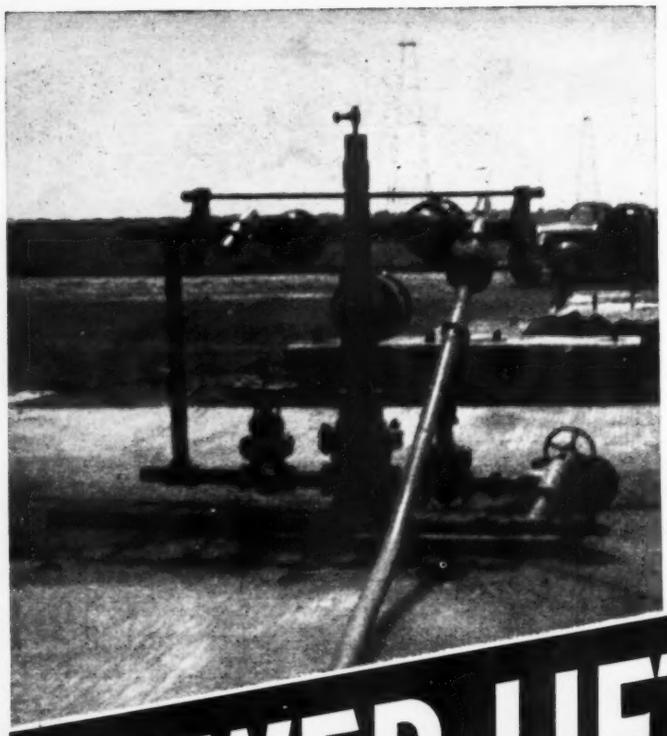
Discharge pressure, lb. per sq. in. gauge	Intake pressure, lb. per sq. in. gauge																			
	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	250	300	350	400
875	231	203	183	168	156	147	140	133½	128	121½	116	107	99	91½	85½	79½	67½	59	52	47
900	232	204½	184½	169	157½	148½	141½	135	129½	123	118	108½	101	93	87	81	69	60	53½	48
925	233	206	186	170½	159	150	143	136½	131	124½	119½	110½	102½	95	89	82½	70½	61½	55	49½
950	234½	207½	187½	172	161	151½	144	138	132	126	121	112	104	96½	90½	84	72	63	56	50½
975	236	209	189	173½	162½	153	145½	139	133½	127	122	113½	106	98	92	85½	73½	64	57	51½
1000	237	210½	190½	175	164	154½	147	140	135	128½	123½	115	107½	99½	93½	87	75	65½	58	52½
1025	238	211½	192	176	165½	156	148	141½	136	129½	125	116	109	101	95	88	76½	67	59½	54
1050	239	213	193	177½	167	157	149½	143	137	131	126	117½	110½	102	96½	89½	77½	68	60½	55
1075	240	214	194½	179	168	158½	151	144	138½	132	127½	119	112	103½	98	91	79	69	62	56
1100	241	215	196	180	169½	160	152	145	139½	133	128½	120	113	105	99½	92	80	70½	63	57
1125		216	197	181½	171	161	153½	146½	140½	134	129½	121	114½	106	101	93	81	71½	64	58
1150		217	198	183	172	162	155	147½	141½	135½	130½	122½	115½	107½	102½	94½	82½	72½	65	59
1175		218	199½	184	173	163½	156	149	143	136½	132	123½	117	108½	104	95½	83½	73½	66½	60
1200		219	200½	185½	174½	165	157	150	144	137½	133	125	118	109½	105	97	84½	75	67½	61
1225		220	201½	186½	176	166	158	151	145	139	134	126	119	111	106	98	86	76	69	62
1250		221½	202½	188	177	167	159½	152	146	140	135	127	120	112	107½	99½	87	77	70	63
1275		222½	203½	189	178	168	160½	153	147	141	135½	128	121	113	108½	100½	88	78½	71	64
1300		223½	204½	190	179	169	161½	154	148	142	136½	129	122	114	109½	101½	89	79½	72	65
1325		224½	205½	191½	180	170	162½	155	149	143	137½	130	123	115	110½	103	90	80½	73	66
1350		225½	206½	192½	181	171	163	156	150	144	138½	131	124	116	111½	104	91½	81½	74½	67
1375		226½	207½	194	182½	172	164	157	151	145	139½	132	125	117	112½	105	92½	83	75½	68
1400		227½	208½	195	183½	173	165	158	152	146	140	133	126	118	113½	106	93½	84	76½	69
1425		228	209½	196½	184½	174	166	159	153	147	141	134	127	119	114½	107½	94½	85	77½	70
1450		229	210½	197½	185½	175	167	160	154	148	142	135	128	120	115½	108½	96	86	78½	70½
1475		230	211½	198½	186½	176	168	161	155	149	143	136	129	121	116½	109½	97	87	79½	71½
1500		231	212½	200	187½	177	169	162	155½	150	143½	137	130	122	117½	111	98	88	80½	72½
1525		232	213½	201	188½	178	170	163	156½	151	144½	138	131	123	118½	112	99	89	81½	73½
1550		233	214½	202	189½	179	171	163½	157	152	145	139	132	124	119½	113	100	90	82½	74½
1575		234	215	203½	190½	180	171½	164	158	152½	146	139½	132½	125	120½	114	101	91	83½	75½
1600		235	216	204½	191½	180½	172½	165	159	153	147	140	133½	126	121	115	102	92	84	76
1625		235½	217	205½	192½	181½	173½	166	160	154	147½	141	134	126½	122	115½	103	92½	85	77
1650		236½	218	206½	193½	182½	174	167	160½	154½	148½	141½	134½	127½	123	116½	104	93½	86	77½
1675		237	219	207½	194½	183½	175	167½	161½	155½	149	142	135½	128	124	117	105	94	86½	78½
1700		238	219½	208½	195½	184	176	168½	162	156	150	143	136	129	125	118	106	95	87	79

[1]Those interested in gas transmission may find it preferable to classify this table under P 624.2, whereas those interested in extraction of natural gasoline may prefer to classify it under P 772.3.



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TOTAL[1] UPWARD PRESSURE AT WELL HEAD BETWEEN TUBING AND CASING, LB.

Casing diam., O.D., in.	Tubing diam., O.D., in.	Well head pressure lb. per sq. in. gauge																	
		1000	2000	3000	3500	4000	4500	5000	5500	6000	6250	6500	6750	7000	7200	7400	7600	7800	8000
14	1¼	137,690	275,380	413,070	481,920	550,760	619,600	688,450	757,300	826,140	860,560	894,980	929,410	963,830	991,370	1,018,910	1,046,440	1,073,980	1,101,520
	1½	137,010	274,020	411,030	479,540	548,040	616,540	685,050	753,560	822,060	856,310	890,560	924,820	959,070	986,470	1,013,870	1,041,280	1,068,680	1,096,080
	2	135,420	270,840	406,260	473,970	541,680	609,390	677,100	744,810	812,520	846,380	880,230	914,080	947,940	975,020	1,002,110	1,029,190	1,056,280	1,083,360
	2½	133,360	266,720	400,080	466,760	533,440	600,120	666,800	733,480	800,160	833,500	866,840	900,180	933,520	960,190	986,860	1,013,540	1,040,210	1,066,880
	3	130,230	260,460	390,690	455,800	520,920	586,040	651,150	716,260	781,380	813,940	846,500	879,050	911,610	937,660	963,700	989,750	1,015,790	1,041,840
	3½	127,280	254,560	381,840	445,480	509,120	572,760	636,400	700,040	763,680	795,500	827,320	859,140	890,960	916,420	941,870	967,330	992,780	1,018,240
	4	123,950	247,900	371,850	433,820	495,800	557,780	619,750	681,720	743,700	774,690	805,680	836,660	867,650	892,440	917,230	942,020	966,810	991,600
16	1¼	183,500	367,000	550,500	642,250	734,000	825,750	917,500	1,009,260	1,101,010	1,146,880	1,192,760	1,238,630	1,284,510	1,321,210	1,357,910	1,394,610	1,431,310	1,468,010
	1½	182,820	365,640	548,460	639,870	731,280	822,690	914,100	1,005,520	1,096,930	1,142,630	1,188,340	1,234,040	1,279,750	1,316,310	1,352,880	1,389,440	1,426,000	1,462,570
	2	181,230	362,460	543,690	634,310	724,920	815,540	906,160	996,770	1,087,390	1,132,690	1,178,000	1,223,310	1,268,620	1,304,860	1,341,110	1,377,360	1,413,600	1,449,850
	2½	179,170	358,340	537,510	627,100	716,680	806,270	895,860	985,440	1,075,030	1,119,820	1,164,610	1,209,400	1,254,200	1,290,030	1,325,870	1,361,700	1,397,530	1,433,370
	3	176,040	352,080	528,120	616,140	704,160	792,180	880,200	968,230	1,056,250	1,100,260	1,144,270	1,188,280	1,232,290	1,267,500	1,302,700	1,337,910	1,373,120	1,408,330
	3½	173,090	346,180	519,270	605,820	692,360	778,910	865,460	952,000	1,038,550	1,081,820	1,125,090	1,168,360	1,211,640	1,246,260	1,280,870	1,315,490	1,350,110	1,384,730
	4	169,760	339,520	509,280	594,160	679,040	763,920	848,800	933,690	1,018,570	1,061,010	1,103,450	1,145,890	1,188,330	1,222,280	1,256,230	1,290,180	1,324,140	1,358,090
18⅝	1¼	248,230	496,450	744,680	868,790	992,900	1,117,020	1,241,130	1,365,240	1,489,360	1,551,410	1,613,470	1,675,530	1,737,580	1,787,230	1,836,870	1,886,520	1,936,160	1,985,810
	1½	247,550	495,090	742,640	866,410	990,180	1,113,960	1,237,730	1,361,500	1,485,280	1,547,160	1,609,050	1,670,940	1,732,820	1,782,330	1,831,840	1,881,350	1,930,860	1,980,370
	2	245,960	491,910	737,870	860,850	983,820	1,106,800	1,229,780	1,352,760	1,475,740	1,537,220	1,598,710	1,660,200	1,721,690	1,770,880	1,820,070	1,869,270	1,918,460	1,967,650
	2½	243,900	487,790	731,690	853,640	975,580	1,097,530	1,219,480	1,341,430	1,463,380	1,524,350	1,585,320	1,646,300	1,707,270	1,756,050	1,804,830	1,853,610	1,902,390	1,951,170
	3	240,770	481,530	722,300	842,680	963,060	1,083,450	1,203,830	1,324,210	1,444,600	1,504,790	1,564,980	1,625,170	1,685,360	1,733,520	1,781,670	1,829,820	1,877,970	1,926,130
	3½	237,820	475,630	713,450	832,360	951,260	1,070,170	1,189,080	1,307,990	1,426,900	1,486,350	1,545,800	1,605,260	1,664,710	1,712,280	1,759,840	1,807,400	1,854,960	1,902,530
	4	234,490	468,970	703,460	820,700	937,940	1,055,190	1,172,430	1,289,670	1,406,920	1,465,540	1,524,160	1,582,780	1,641,400	1,688,300	1,735,200	1,782,090	1,828,990	1,875,890
20	1¼	287,070	574,140	861,200	1,004,740	1,148,270	1,291,810	1,435,340	1,578,870	1,722,410	1,794,180	1,865,940	1,937,710	2,009,480	2,066,890	2,124,300	2,181,720	2,239,130	2,296,540
	1½	286,390	572,780	859,160	1,002,360	1,145,550	1,288,750	1,431,940	1,575,130	1,718,330	1,789,920	1,861,520	1,933,120	2,004,720	2,061,990	2,119,270	2,176,550	2,233,830	2,291,100
	2	284,800	569,600	854,390	996,790	1,139,190	1,281,590	1,423,990	1,566,390	1,708,790	1,779,990	1,851,190	1,922,390	1,993,590	2,050,550	2,107,510	2,164,460	2,221,420	2,278,380
	2½	282,740	565,480	848,210	989,580	1,130,950	1,272,320	1,413,690	1,555,060	1,696,430	1,767,110	1,837,800	1,908,480	1,979,170	2,035,710	2,092,260	2,148,810	2,205,360	2,261,900
	3	279,610	559,220	838,820	978,630	1,118,430	1,258,240	1,398,040	1,537,840	1,677,650	1,747,550	1,817,450	1,887,350	1,957,260	2,013,180	2,069,100	2,125,020	2,180,940	2,236,860
	3½	276,660	553,320	829,970	968,300	1,106,630	1,244,960	1,383,290	1,521,620	1,659,950	1,729,110	1,798,280	1,867,440	1,936,610	1,991,940	2,047,270	2,102,600	2,157,930	2,213,260
	4	273,330	546,660	819,980	956,650	1,093,310	1,229,980	1,366,640	1,503,300	1,639,970	1,708,300	1,776,630	1,844,960	1,913,300	1,967,960	2,022,630	2,077,290	2,131,960	2,186,620
21⅓	1¼	334,700	669,400	1,004,100	1,171,450	1,338,800	1,506,150	1,673,500	1,840,860	2,008,210	2,091,880	2,175,560	2,259,230	2,342,910	2,409,850	2,476,790	2,543,730	2,610,670	2,677,610
	1½	334,020	668,040	1,002,060	1,169,070	1,336,080	1,503,090	1,670,100	1,837,120	2,004,130	2,087,630	2,171,140	2,254,640	2,338,150	2,404,950	2,471,760	2,538,560	2,605,360	2,672,170
	2	332,430	664,860	997,290	1,163,510	1,329,720	1,495,940	1,662 160	1,828,370	1,994,590	2,077,690	2,160,800	2,243,910	2,327,020	2,393,500	2,459,990	2,526,480	2,592,960	2,659,450
	2½	330,370	660,740	991,110	1,156,300	1,321,480	1,486,670	1,651,860	1,817,040	1,982,230	2,064,820	2,147,410	2,230,000	2,312,600	2,378,670	2,444,750	2,510,820	2,576,890	2,642,970
	3	327,240	654,480	981,720	1,145,340	1,308,960	1,472,580	1,636,200	1,799,830	1,963.450	2,045,260	2,127,070	2,208,880	2,290,690	2,356,140	2,421,580	2,487,030	2,552,480	2,617,930
	3½	324,290	648,580	972,870	1,135,020	1,297,160	1,459,310	1,621,460	1,783,600	1,945.750	2,026,820	2,107,890	2,188,960	2,270,040	2,334,900	2,399,750	2,464,610	2,529,470	2,594,330
	4	320,960	641,920	962,880	1,123,360	1,283,840	1,444,320	1,604,800	1,765,290	1,925,770	2,006,010	2,086,250	2,166,490	2,246,730	2,310,920	2,375,110	2,439,300	2,503,500	2,567,690
24⅓	1¼	440,860	881,710	1,322,560	1,542,990	1,763,420	1,983,850	2,204,280	2,424,700	2,645,130	2,755,340	2,865,560	2,975,770	3,085,980	3,174,156	3,262,330	3,350,500	3,438,670	3,526,840
	1½	440,180	880,350	1,320,520	1 540,610	1,760,700	1,980.790	2,200,880	2,420,960	2,641,050	2,751,090	2,861,140	2,971,180	3,081,220	3,169,260	3,257,300	3,345,330	3,433,360	3,521,400
	2	438,580	877,170	1,315,760	1,535,050	1,754,340	1,973 630	2,192,920	2,412.220	2,631,510	2,741,160	2,850,800	2,960,450	3,070,100	3,157,810	3,245,530	3,333,250	3,420,960	3,508,680
	2½	436,520	873,050	1,309,580	1,527,840	1,746,100	1,964.360	2,182,620	2,400,890	2,619,150	2,728,280	2,837,410	2,946,540	3,055,680	3,142,980	3,230,280	3,317,590	3,404,900	3,492,200
	3	433,400	866,790	1,300,180	1,516 880	1,733,580	1,950.280	2,166,980	2,383,670	2,600,370	2,708,720	2,817,070	2,925,420	3,033,760	3,120,440	3,207,120	3,293,800	3,380,480	3,467,160
	3½	430,440	860,890	1,291,340	1,506.560	1,721,780	1,937,000	2,152,220	2,367,450	2,582,670	2,690,280	2,797,890	2,905,500	3,013,120	3,099,200	3,185,290	3,271,380	3,357,470	3,443,560
	4	427,120	854,230	1,281,340	1,494,900	1,708,460	1,922,020	2,135,580	2,349,130	2,562,690	2,669,470	2,776,250	2,883,030	2,989,800	3,075,230	3,160,650	3,246,070	3,331,500	3,416,920

The fact that total well head pressure for unit pressures as high as 8000 lb. per sq. in. is included in the table should not be interpreted as indicating that the casing will have sufficient bursting strength to withstand such pressure. For bursting strength of casing see Table P432.2, p. 257, August, 1937, issue.

[1]Total for lightest weight casing, hence a maximum for each size casing.

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HOUSTON OKLAHOMA CITY LOS ANGELES NEW YORK

Gasification of Crude Oil in Reservoir Sands[1]

Part 2 (Concluded)

By A. B. SHEINMAN, K. K. DUBROVAI, N. A. SOROKIN, M. M. CHARUIGIN, S. L. ZAKS, and K. E. ZINCHENKO

Igniting Oil in Sands

As a safety precaution and to prevent an explosion in bore hole 1 when an ignited substance was lowered in the hole, the gas was pumped from bore hole 2 by means of the vacuum pumps. This procedure created a partial vacuum in bore hole 1 and permitted filling the bore hole with non-explosive air by opening the casinghead to the atmosphere. Filling the hole full of air entirely eliminated the explosion hazard. About 130 to 155 lb. of charcoal lumps 3½ in. in diameter or smaller then were dropped to the bottom of the bore hole. The charcoal was admitted in small portions to avoid bridging and plugging the hole. The charcoal in bore hole 1 then was ignited by dropping a charge of 22 to 25 lb. of red-hot charcoal into the bore hole on top of the unignited charcoal. Special equipment at the casinghead permitted closing the inlet to the bore hole quickly and injecting air to maintain combustion immediately after the last of the burning charcoal was dropped into the bore hole. Air was injected at a rate of 320 to 350 cu. ft. per minute and in one to one and one-half hours the charcoal was completely consumed and the combustion transferred to the oil in the sand, signifying that the normal process had started.

In some of the tests the amount of charcoal introduced into the bore hole was insufficient to ignite the oil in the sands. Consequently some of the experiments using charcoal for ignition were unsatisfactory because of the difficulties experienced in satisfactorily igniting the oil in the sands. Extinguishment of combustion in the sands was quickly indicated by a decrease in pressure in the ignition bore hole (bore hole 1) as well as by an increase in the oxygen content of the gas coming from bore hole 2.

Under favorable conditions the process started almost immediately after the ignited charge was dropped into the bore hole. At the beginning of the process the pressure in the ignition bore hole increased rapidly to 60 lb. per sq. in. owing to the increase of temperature at the zone of ignition and the formation of a large volume of gas. The pressure remained almost constant until flow of gases from one bore hole to the other was established. As soon as there was a normal circulation of gases from bore hole 1 to bore hole 2 and the area of combustion had increased in size, the pressure stabilized at 30 to 45 lb. per sq. inch.

Although difficulties were experienced in some tests when too much unignited charcoal had been dropped into the bore hole and the fine particles plugged the face of the sand, and in one test when the charcoal burned the shoe of the casing and permitted sand to plug the section opposite the producing sand necessitating cleaning the bore hole before the tests could be continued, under favorable conditions operations proceeded smoothly and without interruption. In fact, the tests were so successful that the process could not be interrupted and was stopped only by the exhaustion of the oil or by discontinuing the feed of compressed air to the bore hole.

The tests indicated that if the oil in the sand is of high A.P.I. gravity or if there is only a small amount of oil in the sands about the ignition bore hole, charcoal may not provide a source of ignition for a sufficient length of time to ignite the oil in the sands. This is due to the fact that high-gravity crude oil contains a large percentage of light fractions, which are easily vaporized at relatively low temperatures during the first stages of the application of heat and it is difficult to ignite and maintain combustion of the residual oil, only the heavy ends remaining about the bore hole.

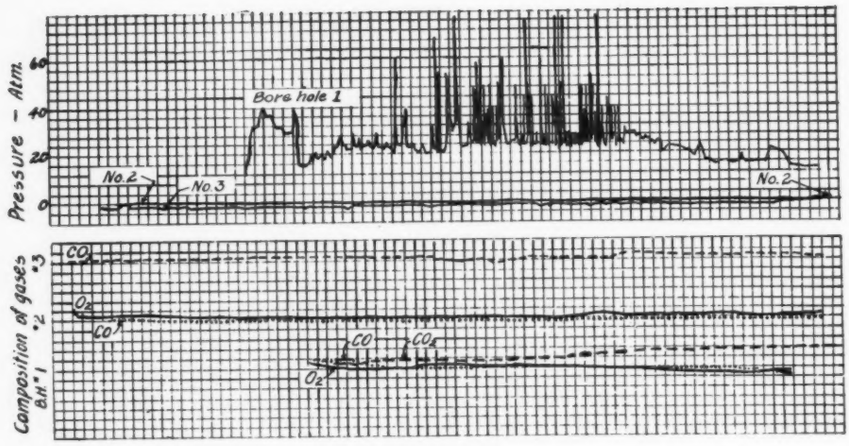
In modified tests in which charcoal was the source of ignition, periodic feeding of crude oil from the surface

TABLE 3

Composition of the gases from bore holes 1, 2, and 3, before and from bore hole 2 during one of the thermal experiments.

Source of sample	Time after first observation, hr.—min.	Composition of gas			Remarks
		CO_2 percent	O_2 percent	CO percent	
Bore hole 1 before ignition	....	0.8	18.2	0	Hole was filled with air during previous experiment.
Bore hole 1 before ignition	0–12	1.0	18.2	0	After previous experiment.
Bore hole 2 before ignition in bore hole 1	0–30	8.2	7.2	0	
Bore hole 3 before ignition in bore hole 1	0–52	9.6	7.2	0	
Bore hole 2 during ignition in bore hole 1	3–10	4.0	10.2	0	
	3–19	3.8	8.2	4.6	
	3–40	7.0	3.4	2.2	
	4–02	8.0	2.6	2.6	
	4–15	8.6	2.8	3.2	
	4–53	8.2	4.8	1.6	
	5–40	7.8	7.6	1.2	
	6–11	6.8	9.4	1.4	
	6–32	6.4	8.4	0.8	
	7–02	8.8	5.0	1.2	
	8–00	7.6	8.8	0.4	
	8–17	6.6	9.6	0.0	
	8–35	6.4	10.0	0.0	
	8–51	7.0	9.8	0.0	
	9–25	7.0	10.0	0.0	

[1]Translated from the Russian Oil Journal *Neftyanoe Khozyaistvo* 28, No. 4, April, 1935, by A. A. Boehtlingk, publisher of Foreign Petroleum Technology, Berkeley, California.



Fog. 7. Typical chart of operations when using charcoal to ignite the oil in the sands

into the ignition bore hole proved a satisfactory method for igniting the oil in the sands. The influence of the liquid fuel fed from the surface was readily noted on the pressure gauge installed in the casinghead of the ignition bore hole. After each admission of fuel the pressure increased immediately the crude oil reached the bottom of the bore hole and became ignited. This method permitted regulating the process to some extent at the surface, thus eliminating the possibility of its discontinuance due to extinguishment of the fire in the bottom of the well.

Samples of gas were taken throughout the experiments and analyzed. Table 2 shows the analysis of the gas coming from the sands under a pressure of 0.2 to 0.4 in. of water before starting the experiments. The gas had an average composition of 27 to 29 percent CO_2; 0.2 to 0.4 percent O_2, and 0.1 to 0.2 percent CO. Table 2 shows also the influence of air injected into bore hole 1 on the composition of the gas from bore hole 2. The composition of the gases from all three bore holes before starting an ignition experiment and the changes in composition of the gas from bore hole 2 during the test are given in Table 3. Fig. 7 is a typical chart of operations when charcoal is used for igniting the oil in the sands. It will be noted from the data given in Table 3 that during the particular experiment the combustion process was not stable and that the combustion showed a tendency to die out toward the end of the experiment. There was no CO in the gas from bore hole 2 at the end of the experiment; the percentage of O_2 had increased rapidly for a time and that of CO_2 had decreased. A simultaneous observation of the gases from bore hole 3 showed that the thermal process taking place between bore holes 1 and 2 had had no effect on the composition of the gas from bore hole 3.

The compositions of the gases from bore hole 2 during other experiments, charcoal being used as the ignition medium, are given in Table 4. During these tests the composition of the gas in bore hole 3 remained essentially unchanged from that shown in Table 3. It should be noted in Table 4 that after injection of air into bore hole 1 was discontinued, causing the thermal process to die out, the oxygen content of the gas from bore hole 2 increased and the CO_2 and CO content decreased. As in a typical gas-producer process, the CO content of the gases at the beginning of the subterranean thermal process was large and decreased toward the end of the combustion. As the process is carried out in the sands, CO_2 is formed, and a decrease in CO_2 content of the gases indicates gradual extinguishing of the combustion. Based on a number of experiments, the average composition of the gases obtained from bore hole 2 approximated 10 to 12 percent CO_2; 1 to 3 percent O_2, and 1 to 1.5 percent CO.

Injecting Hot Gases Into the Oil Sands

In another series of experiments, hot gases or a mixture of hot gases and air were admitted to the ignition bore hole and forced into the surrounding sands. A furnace in which to heat the gases under pressure was constructed of the shell of an old fire-tube boiler (Fig. 8). The outside diameter was 34¼ in. and the length was 13 feet. The ends were made of 25/64-in. flat steel and they became slightly convex when the fur-

TABLE 4

Composition of the gases from bore hole 2 during three experiments using charcoal as the source of ignition.

Time after first observation, hr.—min.	Composition of gases			Remarks
	CO_2 percent	O_2 percent	CO percent	
.....	7.8	6.8	0.4	Experiment conducted on April 15.
0–19	8.0	7.0	0.4	
6–15	6.6	6.8	6.8	
6–51	7.0	5.0	7.6	
7–31	7.8	4.6	4.6	
8–18	7.6	6.0	5.0	
9–16	7.0	5.8	4.8	
10–20	8.2	5.4	4.6	
11–33	10.4	3.8	4.0	
13–12	11.4	2.4	3.0	
14–20	11.8	2.8	2.0	
.....	10.4	3.8	1.6	Experiment conducted on June 18.
0–45	10.4	3.8	1.6	
4–59	8.2	1.4	10.6	
5–35	6.0	1.8	10.6	
6–14	6.4	2.4	7.6	
6–48	8.4	2.4	5.0	
7–32	10.4	1.2	3.0	
9–43	11.8	2.0	3.0	
9–49	10.08	2.0	1.8	
11–03	10.8	4.4	2.2	
11–22	10.8	4.4	2.8	
12–00	10.2	5.2	2.0	
12–43	10.4	4.2	2.0	
13–08	10.6	3.8	1.8	
13–39	11.0	3.4	2.0	
14–20	11.2	2.8	1.6	
.....	9.4	3.0	2.0	Experiment conducted on June 19.
1–06	10.2	3.8	2.0	
1–49	10.2	3.8	2.0	
5–08	9.2	6.4	1.4	Sample taken after feed of air to bore hole 1 was discontinued.

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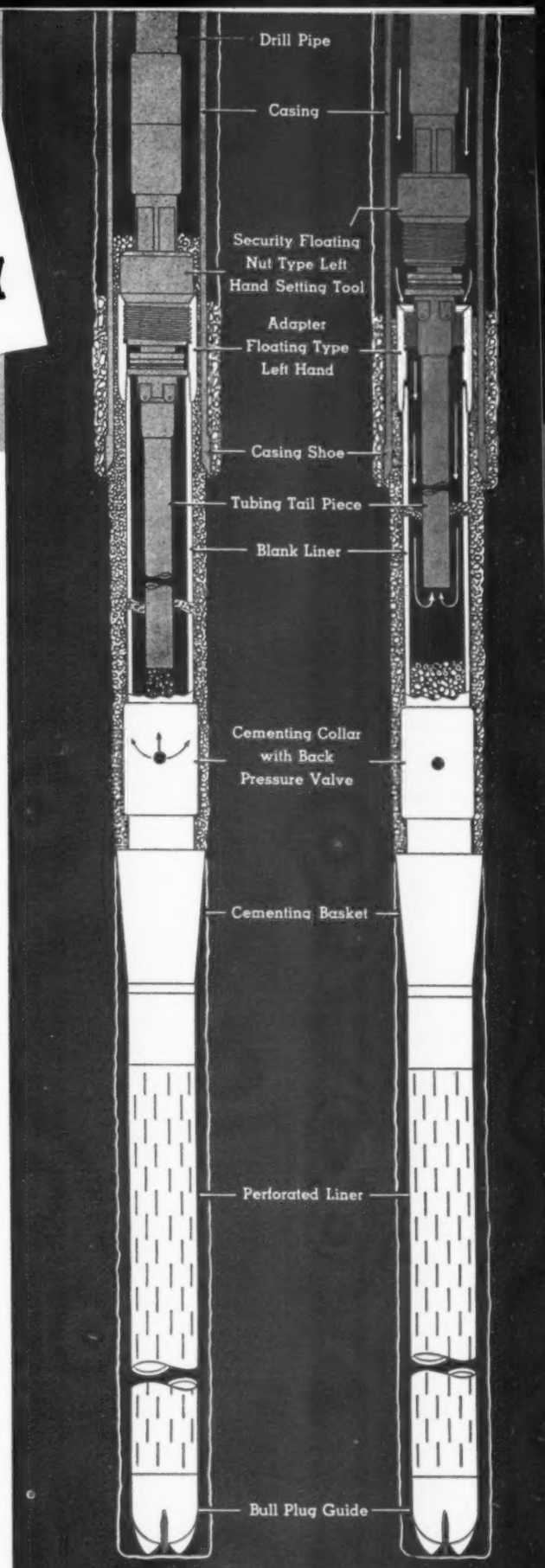

FIG. 1 FIG. 2

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MID-CONTINENT ★ 5525 CLINTON DRIVE, HOUSTON, TEXAS, PHONE CAPITOL 2011

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nace was tested under a pressure of 105 lb. per sq. inch. The furnace was lined with two layers of brick—one layer of ordinary brick covered with a layer of refractory brick. The furnace was provided at one end with a 4-in. pipe, which was connected by a flange to the casing of the bore hole. The opposite end of the furnace was equipped with a short section of 6-in. pipe and a blank flange. An oil burner was installed in the 6-in. pipe. The furnace had a 4-in. "smoke stack" fitted with a valve. A 4-in. pipe was connected into the side of the furnace at a distance of about 5 ft. from the end nearest the bore hole, through which air could be admitted under pressure to the furnace. The fuel for the furnace was admitted through a "lubricator" from small tanks elevated above the burner to give a constant pressure and to insure gravity feed to the burner.

The temperature of the gases fed into the bore hole was measured by means of thermocouples installed in the flange connection on the 4-in. elbow connecting the furnace and the bore hole. At the beginning of the ignition in the furnace, the temperature of the gases leaving the furnace was measured by thermocouples inserted in the flange connection of the smoke stack through which the gases were allowed to escape to the atmosphere until they reached a temperature of 550 deg. fahrenheit. When that temperature was reached the valve in the smoke stack was closed and the hot gases diverted into the bore hole. The temperature of the gases in the furnace was controlled and regulated by varying the rate of feed of fuel oil and by increasing or decreasing the volume of air forced into the furnace. The gases admitted to the bore hole contained 6 to 12 percent free oxygen.

The beginning of the gasification process in the sands about the bore hole was indicated by an increase of pressure as soon as the hot gases reached the oil sands. Fig. 9 illustrates the performance of the process when hot gases were injected into the sands. In normal operations the pressure was almost uniform throughout a test. The relation between temperature and pressure can be noted on the chart, which shows that the latter is a function of the former. Thus, the experiments confirmed the opinion that the reservoir energy can be increased by raising the temperature in the sands.

When crude oil was fed into the bore hole to assist the hot gases in igniting the oil in the sands, the process operated in much the same manner as in the earlier experiments wherein the oil in the sands was ignited by means of burning charcoal. In another series of tests the oil in the sands was ignited by charcoal or wood suspended in a basket above the bottom of the bore hole and ignited by the hot gases from the furnace. It was found that wood placed on the bottom of the bore hole could not be ignited in that manner because the bottom of the hole was below the end of the perforated pipe and the hot gases did not reach the wood but escaped into the oil sands through the perforations above the shoe.

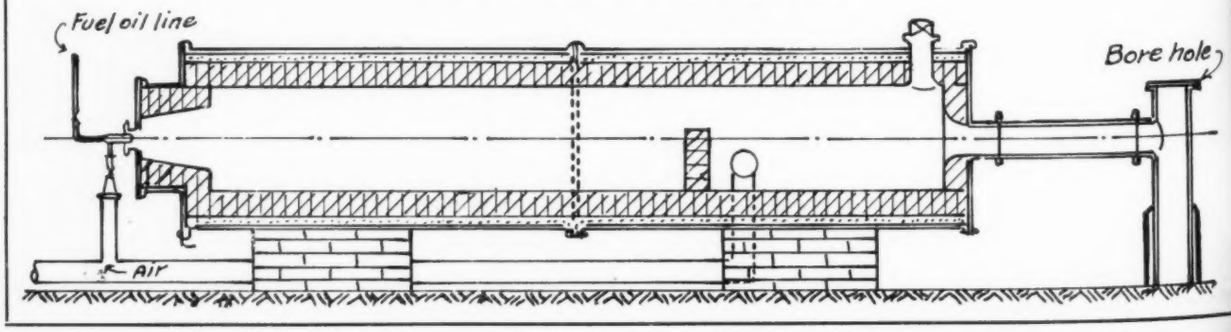
In the experiments designed to determine the possibility of igniting and

TABLE 5

Composition of the gases from bore holes 2 and 3 when maintaining the thermal process between bore holes 1 and 2 by injecting hot gases from the external furnace into bore hole 1.

Time after first observation, hr.—min.	Composition of gas			Remarks
	CO_2 percent	O_2 percent	CO percent	
....	....	....	....	Samples from bole hole 3 June 18.
1–52	19.0	2.6	0.4	
5–12	20.8	2.2	0.4	
5–40	20.8	2.2	0.4	
6–05	21.0	2.2	0.4	
6–39	21.8	2.0	0.2	
7–39	21.8	1.8	0.4	
7–55	21.8	1.8	0.4	
8–25	21.0	1.8	0.4	
8–50	21.6	2.0	0.2	
9–05	21.6	2.0	0.2	
....	10.4	1.0	8.0	Samples from bore hole 2 June 21.
1–41	8.4	2.8	12.0	
2–39	10.0	3.2	5.6	
4–11	9.0	4.6	4.0	
5–24	11.4	3.2	3.2	
6–24	11.4	3.4	1.0	
7–26	11.8	2.8	0.8	
8–28	13.0	2.2	1.4	
9–18	12.4	2.2	1.8	
10–05	11.8	2.8	0.6	
....	9.0	4.0	1.4	Samples from bore hole 2 June 22.
0–50	9.0	4.6	2.8	
1–44	9.4	4.2	2.0	
1–49	9.2	4.4	2.0	
3–09	10.2	4.0	2.0	
3–36	10.4	3.8	1.8	
4–40	10.2	4.2	1.6	

Fig. 8. Cross-section of external furnace



10,000 lbs. test re-pressuring manifold, consisting of Cameron Type "C" Slip Suspension Casing Head Housing and Cameron Type CHR Control Head and Manifold, blown from well when casing and tubing failed under 4,000 lbs. pressure. Note casing and tubing held rigidly in place after being cut off below Casing Head Housing.

DRAMATIC PROOF

CAMERON SLIP-SUSPENSION CASING HEAD

Joint of 7"—Grade "D" seamless casing split lengthwise, causing re-pressuring manifold to be blown 150 feet from the well, carrying with it 3 joints of casing and 3 joints of tubing.

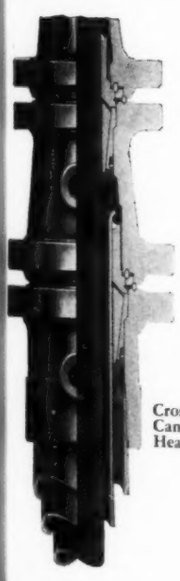
A dramatic demonstration of the strength and rigidity of the Cameron Type "C" Slip Suspension Casing Head was provided recently when a 10,000 lbs. test re-pressuring manifold, flanged above the casing head, was torn from the surface pipe and hurled through the side of a steel derrick for a distance of approximately 150 feet.

Under 4,000 lbs. in-put pressure, a joint of 7"—24-lb. Grade "D" seamless pipe split lengthwise, as illustrated herewith. The 4,000 lbs. pressure caused the 10¾" surface pipe to bell out and collapse at the thread made up in bottom of the Cameron Casing Head Housing. The 7" pipe then parted three joints from the surface. Tubing also parted at this point, and the re-pressuring manifold was blown through the side of the derrick.

The three joints of 7" pipe shown were carried with the manifold, being held rigidly to it by the Cameron Slip-Suspension Casing Head Housing. Three joints of tubing, gripped between the rams of a Cameron Type CHR Control Head, also were carried with the manifold.

When the 7" casing and the tubing were cut off below the casing head with a welding torch, both strings were found to be perfectly concentric, and as rigidly supported as when they were originally locked in position. The manifold was returned to the shop and dismantled for inspection, where it was found that the 7" pipe remained unmoved and unswaged in the slips, and that the construction weld at the top of the auxiliary welding hanger remained exactly as when applied. After the routine inspection, the casing head was again assembled and placed in service.

To operators interested in the constructional details of a casing head that will easily withstand every demand that can be made upon it, complete information concerning Cameron Slip-Suspension Casing Heads will gladly be provided on request.



Cross-section illustration of Cameron Type "C" Casing Heads in a 3-string hook-up.

Left—Top view of hanger assembly, after dismantling re-pressuring manifold, showing construction weld around casing in exactly the same condition as when applied. This weld prevented pipe from being swaged in slips.

Right—Bottom view of hanger assembly showing slips undisturbed.

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TABLE 6

Analysis of crude oil from bore hole 3. (Distillation by the Glinskii method)

Boiling points of fractions in deg. cent.	Percentage of fraction	Cumulative percentage	Density at 15 deg. cent.	
			Individual fraction	Cumulative fraction
80–100	7.28	.....	0.694	.....
140–160	17.08	24.90	.759	0.740
180–200	8.78	33.68	.811	.755
260–270	13.73	47.41	.846	.....
Residue+loss in distillation	62.59	.....	.956	.....

Density of crude oil at 15 deg. cent. = 0.847 = 35.6 deg. A.P.I.
Density of residue at 15 deg. cent. = 0.956

maintaining combustion of wood in a mixture of hot gases and air, a small bundle of wood in a metal basket was suspended on a small steel cable in the bore hole in the path of the descending gases. (Fig. 10.) After a period of time the basket was withdrawn from the bore hole and it was found that the hot gases had burned the entire contents of the basket, leaving no residue. The hot gases, however, did not ignite the wood at the bottom of the hole, showing that they had entered the oil zone through the perforated section of the casing above the wood.

When hot gases are injected into the sands while a source of combustion is maintained at the bottom of the bore hole, the composition of the gases emitted from the sands is relatively stable, as it can be controlled in a measure from the surface of the ground by regulating the composition of the input gases. Basically, the composition of the gases recovered when the external furnace was used differed but little from that of the gases produced during the earlier thermal experiments although they were characterized by their greater stability.

When the furnace was used and hot gases were injected into the sands the tendency of combustion in the sands to die out, as indicated by an increase in the O_2 content of the emitted gases and a lowering of the CO_2 content, was not observed. In fact, throughout the experiments the percentages of the components of the gases fluctuated between very close limits. For all the experiments in which the furnace was used the gas from the producing bore hole contained an average of 10 percent CO_2, 5 percent O_2, and 0.1 percent CO.

For some unaccountable reason the amount of oxygen in the gas in some tests was as much as 12 percent. As the combusion in the furnace was regulated as nearly perfectly as was humanly possible, it is thought that the large oxygen content may have been due to the fact that in some part of the oil zone the oil did not ignite in the short time allotted to each experiment and that the combustion occurring at the bottom of the hole and in the immediate vicinity of the bore hole did not consume the anticipated amount of oxygen. The heat generated by the limited amount of combustion, however, seemed to have been sufficient to vaporize the light fractions of the oil in the sands at a distance from the bore hole. The high calorific value of the recovered gas, therefore, was due to the evaporation of the light gasoline fractions of the oil.

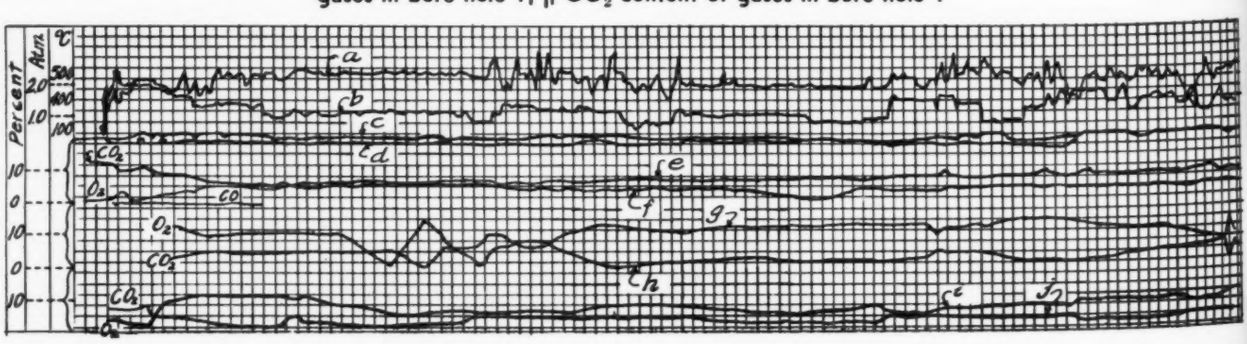
Characteristics of the Recovered Gas

The spreading of the thermal process in the oil zone away from the ignition bore hole was indicated by the changes in composition of the gases from bore hole 3. Whereas in the first experiments (without the furnace) the composition of the gases from bore hole 3 remained constant, during the experiments in which hot gases from the furnace were injected into the ignition bore hole the O_2 content of the gases from bore hole 3 increased, and that change was accompanied by a decrease in CO_2 and the appearance of CO. In fact, it was apparent that there was a tendency for the gases in the sand to diffuse and reach equilibrium in composition as was noted when the gases taken from bore hole 3 one week after the experiments were completed were found to have the composition given in Table 5. The analysis of the gas from bore hole 3 showed that during that week the CO_2 content had decreased to 12 percent, the O_2 content increased to 3.6 percent, and the percentage of CO was 1.4. Thus, the gas was similar in composition to the gases from bore hole 2 although the thermal process had occurred only between bore holes 1 and 2 and had not yet begun between bore holes 2 and 3.

The gases had a pungent odor and affected the eyes and the mucous membrane of the nose. Doubtless the gases contained unsaturated hydrocarbons. The gases coming from bore hole 1 during clean-out periods had an even greater effect than the other gases on the eyes and mucous membranes of the nose and throat. They contained considerable sulphur gas, which evidently was formed by high-temperature decomposition of the iron pyrite in the sands.

The calorific value of the gas was not the same after the experiments as it

Fig. 9. Chart of operations when using the external furnace. a, temperature of gases fed into bore hole 2; b, pressure in bore hole 2; c, pressure in bore hole 1; d, vacuum in bore hole 3; e, CO_2 content of gases in bore hole 3; f, O_2 content of gases in bore hole 3; g, O_2 content of gases in bore hole 2; h, CO_2 content of gases in borehole 2; i, O_2 content of gases in bore hole 1; j, CO_2 content of gases in bore hole 1



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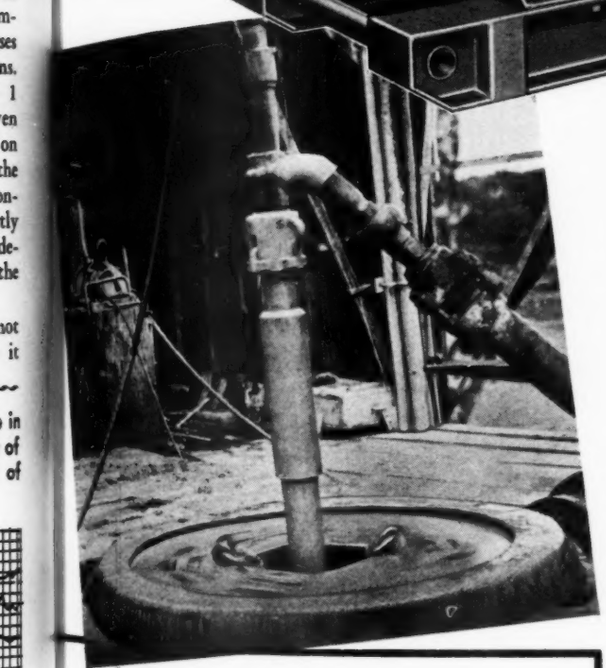

ROTATING WITH 13,000 ft. of 18-lb. drill pipe suspended from slips in the table while circulating in heaving shale.

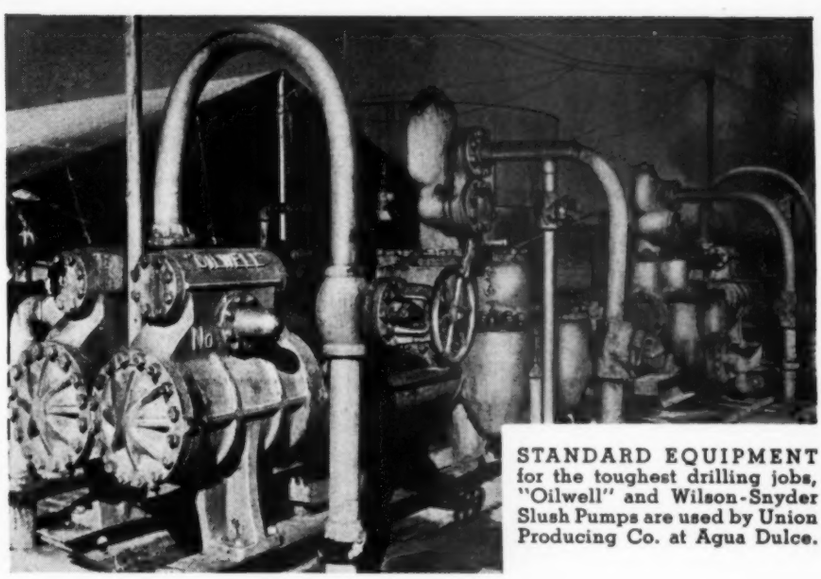

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TABLE 7

Properties of the condensate (distillates) collected in the traps located ahead of and in the discharge line from the cooler.

Specific gravity = 0.775 (51.1 deg. A.P.I.)
Initial boiling point = 78 deg. cent.

Temperature, deg. cent.	Percent over, cumulative
90	1.0
100	2.5
110	7.5
120	18.0
130	29.5
140	44.0
150	56.0
160	67.5
170	75.0
180	83.0
190	88.5
200	92.0
210	94.0
220	96.6
227 (E.P.)	97.0

was before they were undertaken. At the beginning of the tests, natural gas filled the bore holes and was emitted from the sands under the pressure of the injected air. The natural gas was rich in methane and contained 28 to 29 percent carbon dioxide. Its composition, however, changed rapidly during the thermal process.

The heat content of the gases obtained during the gasification experiments ranged from 485 to 595 B.t.u. per cu. ft. and averaged 560 B.t.u. The gas burned with a bright yellow flame when ignited at the discharge of the vent pipe.

Crude Oil Produced During Tests

On account of the low saturation of the oil sands there was some doubt before the experiments were started whether crude oil would be produced. In fact, a suggestion was made that it might be advisable, in order to carry on the thermal process in the oil sand and to study its workings, to admit 10 to 15 bbl. of crude oil to the sands around the ignition well. Fortunately, as was learned later, no oil was added to the sands and the experiments were carried out without creating any artificial conditions in the sands.

The pump in bore hole 2 was started immediately after the ignition experiments were begun. As a result of the experiments with wood charcoal as the igniting agent a large stream of crude oil was pumped from bore hole 2. Later, when the external furnace was used and hot gases were injected into the oil zone through bore hole 2, a column of oil 13 ft. high accumulated in bore hole 3.

The results of the distillation tests on the crude oil produced from bore hole 3, as a result of the experiments with the external furnace, are given in Table 6. It will be noted from the data given in the table that the crude oil was deficient in light fractions, which may be explained as having been the result of the action of high temperature on the crude oil in the sands.

Thus, even under conditions of low oil saturation of the reservoir sands, not only were gases of high calorific value obtained but liquid crude oil also was produced as a result of the process. Although the total amount of crude oil recovered was small, nevertheless the appearance of a column of oil in a completely "dry" bore hole shows the efficiency of the thermal process for recovering oil from "depleted" sands. The fact that the day after the experiments were terminated and 24 hours after the oil had been bailed from bore hole 3, a column of crude oil again appeared in the bore hole indicates that the sands for some distance about the bore hole had become saturated with oil during the experiments and that this oil would flow to the bore hole. This seemed an important finding as prior to the experimentation no oil appeared in any of the bore holes even after long standing. With the exception of a small amount of water produced from bore hole 2 during the thermal experiments, the crude oil produced was free of water.

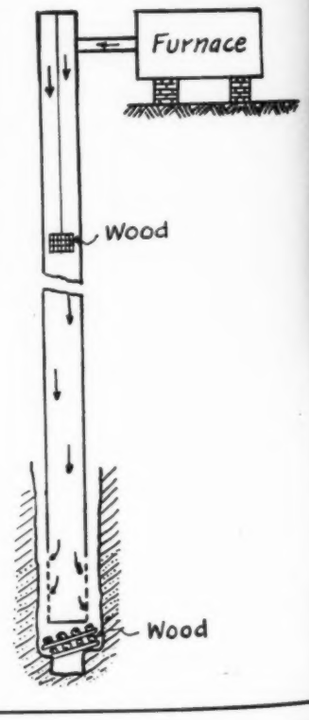
The distillates that collected in the line to the cooler and in the discharge line from the cooler showed definite indications of being a product of cracking. They contained the gasoline-kerosene fractions (gasoline fractions predominating) and had the properties given in Table 7. In addition to the gasoline produced in the distillates, the gas from the wells contained 1.5 to 1.7 gal. of gasoline of high A.P.I. gravity per 1000 cu. feet.

Close Spacing Not Necessary for Success of Process

The experiments showed that the influence of the thermal process is not limited to an area immediately adjacent to the ignition bore hole. Although every effort was made prior to starting the experiments to seal all the abandoned wells in the vicinity of the experimental bore holes so no gas could escape through them to the atmosphere, through an oversight one nearby well was not sealed and remained open during a part of the experimental work. The well was inspected regularly and for some time showed no signs of life but after a number of experiments had been performed the well began to produce considerable amounts of gas. The well was then sealed with a wooden plug and a cement cap. A ½-in. pipe provided with a valve was inserted through the center of the plug and cap to facilitate taking samples of the gas. Subsequently six other abandoned but capped wells in a northeasterly direction and respectively 110, 175, 220, 240, 255, and 270 ft. from bore hole 2 were tested and all showed increases in pressure, the maximum being 1.2 lb. per sq. inch.

From the data collected during the experimentation it was concluded that the injection of air at the rate of 21,000 cu. ft. per hour resulted in the production of gas at the rate of about 42,000 cu. ft. per hour. As the influence of the process had not extended very far from the ignition bore hole the gas produced from the distant wells still had the composition of natural gas. Eventually, of course, the injected air would contaminate the gas and its composition would approach that of the gas produced from bore hole 3 during the experiments. The production of gas from the distant wells, however, proved conclusively that under favorable conditions of permeability in the reservoir the spacing between ignition and producing wells might be as much as 600 feet.

Fig. 10. Method of hanging a basket of wood in the bore hole in the path of the descending hot gases



TO GO DEEPER

A STAB, A SPIN, AND IN SHE GOES! *Two men guiding a section of* NATIONAL *Seamless Drill Pipe into threads that are correctly designed to resist damage during making up. Twist-offs and wash-outs are mighty rare with* NATIONAL *Seamless because of its uniform wall strength—Walls Without Welds!*

"THAT'S WHY NATIONAL PIONEERED SEAMLESS DRILL PIPE"

TWENTY-FIVE years ago, oil men knew they would have to drill deeper to keep pace with the growing demand for petroleum. What they needed most was better, stronger drilling equipment.

NATIONAL Tube was already researching in seamless manufacture and promptly concentrated its energies on developing a better drill pipe. And as a result of this research, in 1914, NATIONAL introduced the first *Seamless* Drill Pipe. Seamless was a success from the start, simply because it had the necessary stamina to penetrate deeper, through the toughest types of sub-strata.

Today, drillers drive their bits down 15,000 feet and more, three times farther than in the pre-1914 days. All-round improvements in both equipment and drilling technique, to be sure, deserve much of the credit for the advance—but the fact remains that it wouldn't have been possible to tap that great subterranean store of oil without the pioneering work in Seamless carried on by NATIONAL Tube.

Though materially improved, Seamless Drill Pipe is still fundamentally the same—pierced from a solid billet of steel. No other drill pipe has ever been able to out-perform NATIONAL Seamless.

This is the kind of achievement which has made NATIONAL Tube Company the Oil Industry's Headquarters for tubular goods. NATIONAL does not wait for the need to become acute before starting the search for a solution. Its improvements are ready *when you need them.* That's why NATIONAL Tube means the finest and newest in tubular goods, wherever oil is produced, transported, or refined.

SOME OUTSTANDING DEVELOPMENTS PIONEERED BY NATIONAL TUBE

- Seamless Drill Pipe
- Seamless Upset Tubing
- Seamless Long Threads and Couplings
- Seamless Grade D Casing
- Seamless High Tensile Couplings
- Seamless Rounded Form of Thread
- Seamless Electro-Galvanized Threads and Couplings
- Seamless Normalized Tubing Grade C for Corrosive Conditions
- Seamless Cement Lined Casing and Tubing

To be sure of getting the newest, most up-to-date improvements in Drill Pipe, Casing, and Tubing, always specify NATIONAL Seamless. NATIONAL's policy is to bring you finer, stronger tubular goods, and bring them to you FIRST!

NATIONAL TUBE COMPANY

PITTSBURGH, PA.

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

Conclusions

The following conclusions were drawn from the experiments:

1. Oil in commercially depleted sands can be ignited and combustion maintained in the sands away from the well bore.

2. The oil in the sands may be ignited by:

   a. charcoal,

   b. charcoal augmented by charges of oil,

   c. hot gases injected into the reservoir,

   d. hot gases injected into the reservoir to ignite charges of oil admitted to the ignition bore hole,

   e. hot gases injected into the reservoir to ignite wood or charcoal placed near the bottom of the ignition bore hole.

3. The gas produced as a result of the gasification of oil in the sands had an average heating value of 560 B.t.u. per cu. foot.

4. Crude oil is made to flow from the sands to wells from which it can be pumped.

5. Distillates (gasoline and naphtha) were produced, indicating that the process is technologically complex and includes all types of thermal effects such as gasification, pyrolysis, distillation, and condensation. The discharged gases contained as much as 1.7 gal. of gasoline per 1000 cu. feet.

6. The oil sand acts as an accumulator of heat and all heat supplied to the sands is used in the process.

7. The influence of the process may spread over a large area.

8. No equipment other than that used in the oil fields is required to carry out the process on a commercial scale.

9. On the basis of work done so far, the subterranean gasification of crude oil in reservoir sands and the thermal method of producing oil can be accepted as being solved in principle. On the basis of the tests carried out in zone "E" of the Shirvanui field and the experience gained during the experiments there seems no logical reason why similar operations on a larger scale should not be equally successful. Obviously, certain details must be worked out as they arise and each area must be studied individually to determine the best manner of carrying out the process and the methods best suited for the particular area.

P 094.6

How to Estimate the Horsepower Transmitted by Any Belt

THE following method will give a close approximation of the horsepower required to drive any belt-operated machine. It makes no difference whether the belt is made of leather, rubber, canvas, hair, or other substance. The method is applicable to V-belts also.

If we measure the simultaneous total tension on the tight side and on the slack side of a belt drive and if we know the speed of the belt in ft. per min., it is a simple matter to calculate the actual horsepower being transmitted. To determine belt speed is easy. The unusual task is that of measuring the belt tensions—a thing that *can* be done.

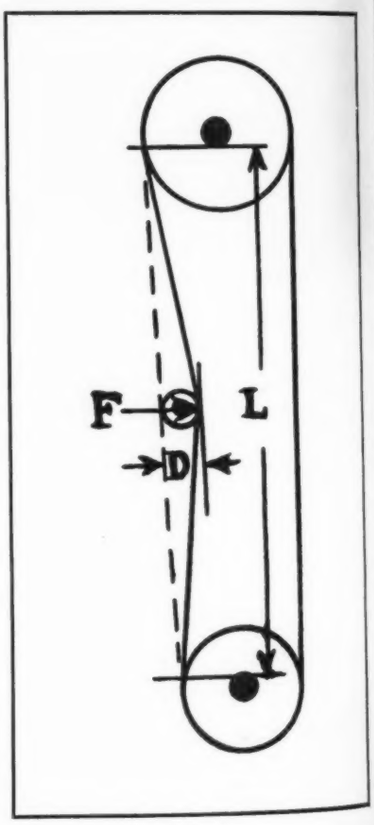
The accompanying sketch shows how belt tension can be determined not only when a machine is standing idle but when it is in motion.

Press a light idler pulley against the mid-point of the belt deflecting it as indicated in the sketch. Let us call the deflection D. Measure the force, F, in pounds required to produce the deflection and measure the distance deflected, D, in inches. Then measure the distance, L, between points of tangency on the pulleys as shown in the sketch, also in inches. For approximate computations this distance, L, can be assumed to be the distance between shaft centers in inches. To determine the belt tension multiply the force, F, in pounds required to deflect the belt by the distance, L, in inches. Then multiply by 0.25. Divide the product by the deflection, D, in inches. The result is the tension in the belt in pounds.

Do the same on the slack side in precisely the same way. If possible, determine the tension in both sides simultaneously, as results will be more nearly accurate.

Next, subtract the tension in the slack side from the tension in the tight side. The result is the so-called "effective pull" in pounds.

Finally, to determine the horsepower transmitted multiply the effective pull in pounds by the velocity of the belt in ft. per min. Belt velocity can be determined by referring to tables[1] commonly found in standard handbooks and catalogs. Lastly, divide that product by 33,000. The result is the horsepower transmitted to the machine.



[1] *The Petroleum Engineer*, Table P 094.603.1, Sheets 1 and 2, Vol. 9, Jan. 1938, p. 133, and Vol. 10, Nov. 1938, p. 145.

Ton-Mile Service Records *prove* Excellay Economy

EXCELLAY Preformed Rotary Lines are constantly growing in popularity for one important reason—*economy*. We have recommended that users of Excellay Preformed Rotary Lines keep ton-mile service records and, where this has been done, the result has always been further proof of the economical service Excellay Preformed Rotary Lines can give.

This economical performance is due to the fact that in Excellay Preformed Rotary Lines a more even distribution of load is secured. They resist fatigue and whipping—offer ease and safety in handling, are more flexible and spool better on the drum. Furthermore, these lines are fully lubricated inside and out with a high-grade lubricant.

Check over these important advantages. Each of them means *economy*. Together, they are an indisputable reason why you should let American Tiger Brand Excellay Preformed Rotary Lines go to work for you.

AMERICAN STEEL & WIRE COMPANY
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United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

P 425.25

The Chemical Control of Heaving Shale[1]

Part 2 (Concluded)

By CHESTER L. BAKER, Philadelphia Quartz Company, Philadelphia, Pennsylvania

and

ALLEN D. GARRISON, Assistant Professor of Chemical Engineering and Physical Chemistry, The Rice Institute, Houston, Texas

Formulation of the Drilling Mud

In shallow drilling almost any fluid suspension of clay in water can be used as a drilling mud. With progressively deeper wells, however, the mud must be held to ever stricter requirements. The cost of continuously pumping the mud down the drill pipe to the bit and out the hole becomes an appreciable item in a 10,000-ft. hole and requires that the viscosity be held at a minimum. The mud must be thixotropic so that when circulation is stopped a gel will be formed that is sufficiently strong to hold the weighting material and rock cuttings in suspension and not allow them to fall to the bottom of the hole and hopelessly jam the bit. On the other hand the gel strength must be low enough so that circulation can be started again at reasonable pump pressure. It is very important that the mud quickly form a thin, impervious filter cake on the hole wall wherever a porous material is penetrated. The more quickly the filter cake is formed the smaller the loss of valuable mud into the formation. The clearance between the hole being drilled and the casing later to be run is often not more than an inch, so a thick filter cake cannot be tolerated. A mud that forms too thick a filter cake may be the cause of hopelessly repeated reaming and even of a stuck pipe. The mud must be adaptable to reconditioning for further use, that is, removal of rock cuttings and gas bubbles and readjustment of its physical characteristics when altered by materials drilled.

The strongly flocculating character of the silicate solution required to hold the heaving shale, as contrasted with the deflocculating condition ordinarily maintained in drilling mud, presented special difficulties that were solved only through the perfection of measuring methods and considerable study.

The thixotropic gelling rate and the gel strength attained are perhaps the most important characteristics in a drilling mud. Some judgment of this characteristic may be made by shaking air bubbles into a jar of mud and then, holding the container in an inclined position, observing the maximum size of the bubbles that become locked in place by the gelling. The method of measurement finally found most useful involved the use of the Stormer Viscosimeter. The instrument is set where it can be free of vibration, and water of the desired temperature circulated through the jacket. The cup is filled with mud and allowed to come to temperature. The spindle is rotated rapidly for at least 100 revolutions and then allowed to stand quiescent for the predetermined length of time. The applied weight in grams that will then just start and continue rotation of the spindle is taken as a measure of gel strength. A plot of gel strength versus time reveals much concerning a drilling mud. This method is subject to criticism but gives reproducible results in experienced hands and permits the quantitative evaluation of drilling muds.

Biographical sketches and photographs of the authors will be found on page 50 of the January issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

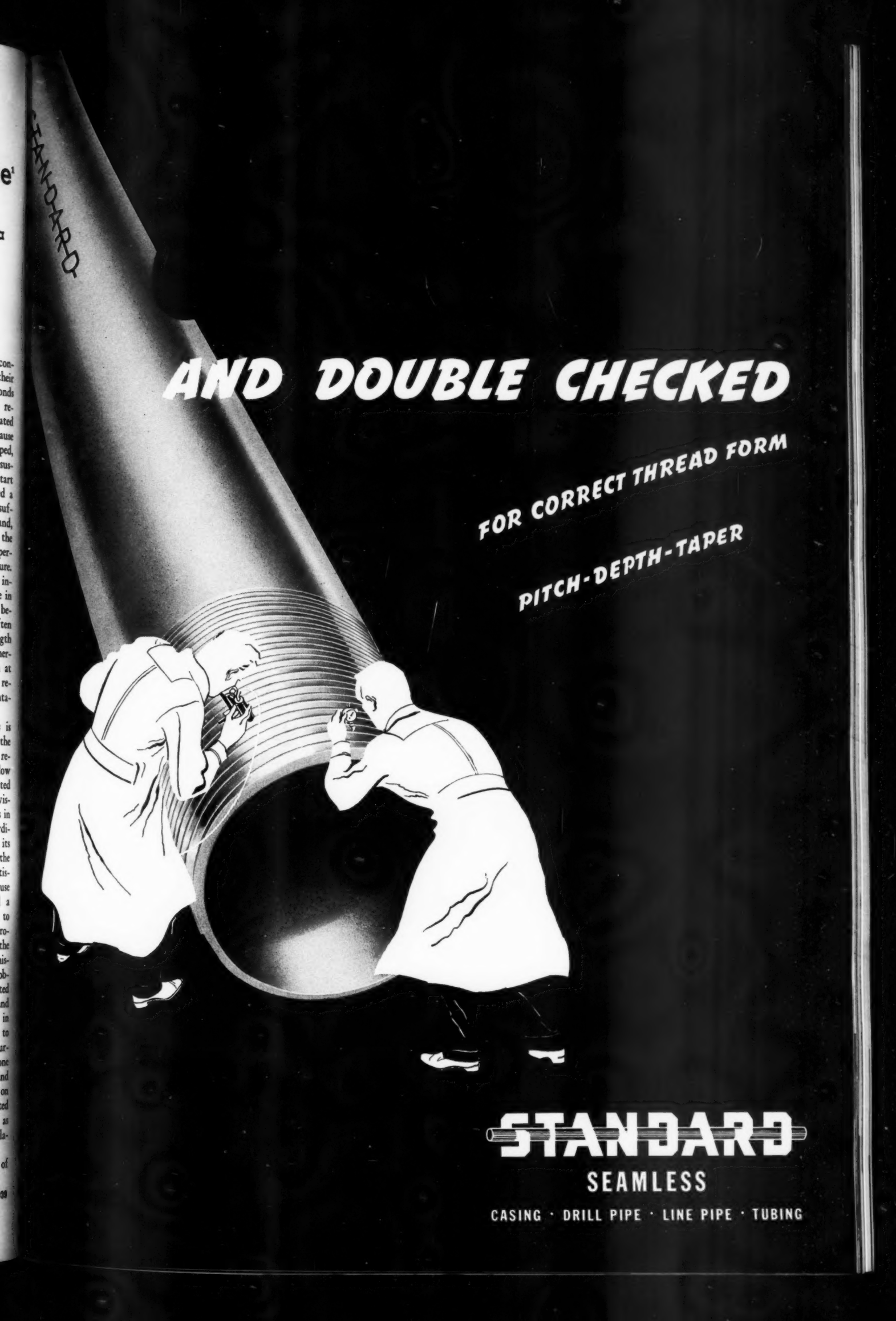
If dry, powdered clay is stirred into the strong "D" Brand—NaCl solution the resulting suspension has virtually no gel strength. This at first seemed an insuperable obstacle. Hydrating the clay in water before mixing with the silicate helped a little but bad settling-out was experienced. The solution was finally found in the use of bentonite. This highly colloidal clay, when first suspended in water for about 24 hours and then mixed with the silicate, is very effective. Usually less than one percent in the final mud gives a gel of sufficient strength.

The strongly silicated and flocculated drilling muds here under consideration were found to develop their ful gel strength in a matter of seconds instead of the minutes or hours required by an ordinary deflocculated mud. This is a real advantage because in the hole, when circulation is stopped, the rapidly forming gel seizes the suspended cuttings before they can start to fall. As they have not acquired a downward velocity, a weaker gel suffices to hold them. On the other hand, when it is desired to start flow of the mud column again, this weaker gel permits the use of lower pump pressure. These muds also show a favorable increase in gel strength with increase in temperature, in contrast to the behavior of ordinary muds, which often show a dangerous drop in gel strength at bottom-hole temperatures. Furthermore the lowering of gel strength at surface temperatures facilitates the removal of gas and sand by sedimentation in the mud ditch.

The viscosity of drilling muds is usually measured by means of the Marsh funnel. The time in seconds required for a given volume to flow from the funnel through a calibrated orifice is taken as a measure of the viscosity. No allowance for differences in specific gravity or thixotropy is ordinarily made, and the method finds its greatest value as a rough tool in the hands of the laborer. The most satisfactory instrument for laboratory use is the Stormer Viscosimeter, and a modified procedure must be used to eliminate error due to thixotropy. Provision should be made to hold the sample at well temperature as a misleading value will otherwise be obtained. The instrument is calibrated with standard glycerine solutions and a chart drawn relating viscosity in centipoises to the weight required to turn the rotor at 600 r.p.m. In measuring a mud, the operator tries one weight after another until one is found that gives a speed of 600 r.p.m. on three successive runs. The repeated stirring of the sample is regarded as valuable in removing any latent gelation.

A solution comprising a mixture of

[1]Presented at meeting of American Institute of Chemical Engineers, Philadelphia, Pennsylvania, November 9-11, 1938, and published in *Trans. Am. Inst. Chem. Eng.*, Vol. 34, No. 6, Dec., 1938.


STANDARD
AND DOUBLE CHECKED
FOR CORRECT THREAD FORM
PITCH-DEPTH-TAPER
STANDARD
SEAMLESS
CASING · DRILL PIPE · LINE PIPE · TUBING

two volumes of "D" Brand silicate of soda and one volume of saturated sodium chloride solution has a viscosity of about 29 centipoises at 30° C. This sets a lower limit on the attainable viscosity in the mud. The upper limit is set by the amount and character of the suspended solids required to give the desired gel strength and specific gravity. It is usually not difficult to achieve a viscosity as low as 50 centipoises.

Ordinary drilling mud tends to become more viscous with use owing to solids picked up from the drilling, and it is common practice to cut back the viscosity with water or a fraction of a percent of deflocculating agent. The only effective means of reducing the viscosity of the protective silicate muds is by good settling of rock particles and dilution with the silicate—NaCl solution required as an aqueous phase. It was feared at first that this would be an economic handicap, but experience has shown that it is seldom necessary to add more liquid phase than is required to compensate for the new hole drilled. This, of course, should have been expected from the fact that the aqueous phase was designed to prevent dispersion of the shales drilled.

The attainment of any reasonable specific gravity in the mud presented no difficulty. Sample muds prepared with pulverized barytes, iron oxide, or silica showed no significant change in measurable characteristics after storing for a month at 90° C. Muds weighing 16 lb. per gal. have been successfully built and used in the field.

Trouble was anticipated with the building of a mud that would quickly form a thin, impervious filter cake on the wall of the hole because flocculated clay suspensions, as a rule, tend to form thick pervious filter cakes.

A preliminary test method was devised of placing 40 ml. of the mud in a number 40 Whatman filter paper held in a standard 60° long-stem filter funnel and observing the rate of filtrate accumulation. Experience has shown that a cessation of flow in 24 hours or less and a total filtrate volume less than 12 ml. indicate a mud that is likely to give satisfactory performance in the hole. Such a test has continued to be used in the field. Recently more refined tests have been made using a flat filter disc and pressure of 100 or more lb. per sq. in. This method has the advantage of greater speed and more nearly exact duplication of the conditions ambient in the hole, but owing to the nature of the equipment required is best suited to laboratory studies.

The problem in its simplest terms resolved itself into that of providing a proper distribution of solid particle sizes in the mud. In the early wells the right particle sizes were obtained by using properly ground minerals. It was later found that the watermud built-up in drilling the formation above the heaving shale provides nearly the right proportion of different particle sizes, and that the needed adjustment can be accomplished by the addition of dry pulverized bentonite directly to the silicate mud.

The "D" Brand silicate chosen for this work was known to be highly reactive not only with di- and poly-valent cations, but also with certain solid minerals likely to occur in the shales being drilled, and it was feared that unfavorable changes in the mud characteristics were likely to occur in the hole. To evaluate these dangers a systematic laboratory study of all known factors, requiring several months' time, was undertaken. Muds were made in all practical combinations of the "D" silicate-NaCl solution with commercial mud-making clays, weighting materials, and many pulverized samples of shale. Concentrations of single materials and combinations of them were correlated with resultant mud properties such as viscosity, gel strength, gel rate, filter caking behavior, and settling characteristics.

For the most part, these experimental muds were stored for a month at 90° C. and their behavior during, and their characteristics after, this treatment observed and measured. The guidance afforded by this work has proved invaluable. The outstanding revelation of this work was that the silicate—NaCl muds are outstandingly resistant to change. This has been amply confirmed in the later field work and may yet prove sufficient reason for

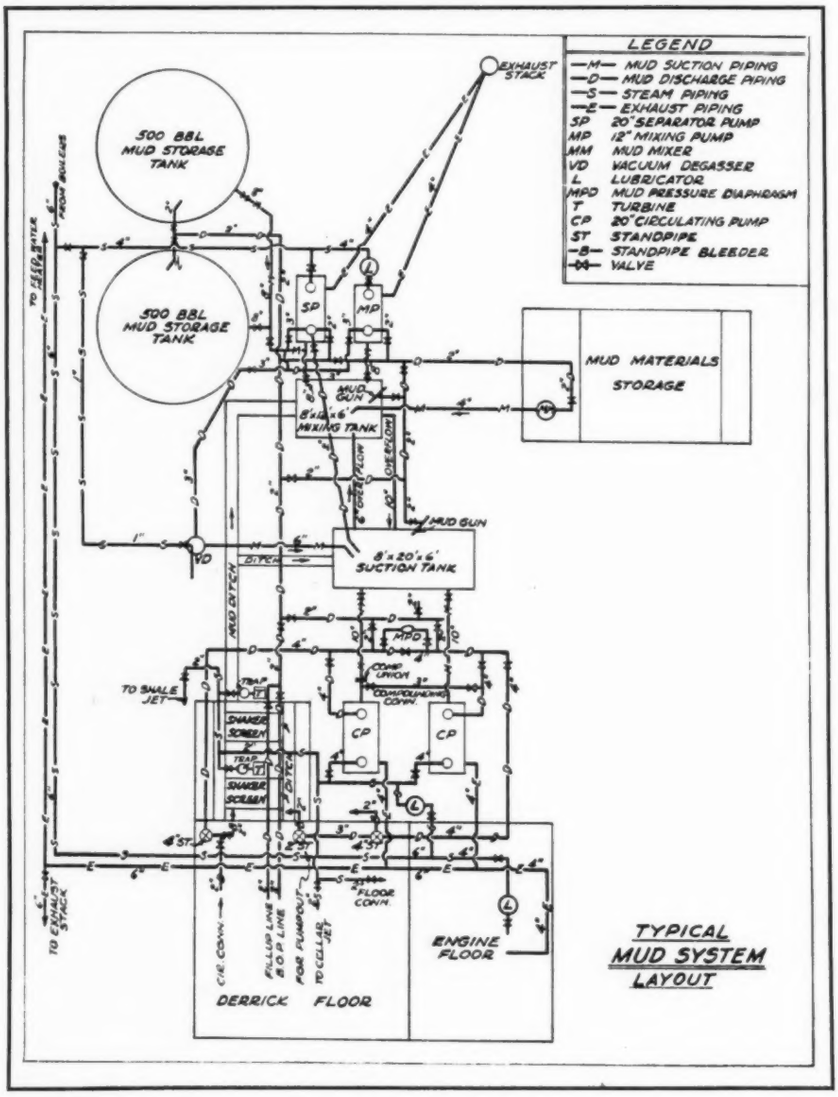


Fig. 7. Typical layout of surface equipment for mixing, reconditioning, and circulating protective silicate mud

using them even when heaving shale is not encountered.

Location of Heaving Shale in the Well

The present field practice and equipment has been evolving through experience with 17 wells to date. Space here does not permit a detailed narrative of these cases, but an attempt will be made to describe present preferred practice.

It is first necessary to locate the top of the heaving shale. Its approximate position may be known from experience with adjacent wells. In any case, two practices should be adopted at least 2000 ft. above its anticipated level. First, frequent cores should be taken and before any evaporation has occurred representative samples should be shaved free of mud and other contamination and preserved in air-tight containers. Representative portions of these should be immersed in companion test tubes, one charged with water and the other with a solution comprising two volumes of "D" Brand plus one volume of saturated sodium chloride brine. These test tubes should be carefully labeled and preserved. Any cracking, swelling, or disintegration of the samples in the water is warning that heaving shale has been tapped. Second, a careful record should be kept of mud characteristics, drilling progress, and any additions made to the mud. A decided increase in the mud viscosity is a real danger signal, and should be checked by taking a core immediately and performing the test-tube test. An agreement in these tests is taken as proof that the heaving shale has been tapped.

It cannot be too strongly emphasized that once heaving shale has been reached further drilling should be stopped and a change to protective silicate mud made before drilling is resumed. In altogether too many cases the operator is inclined to go on only to find after 24 to 48 hours that he is in serious trouble. With several hundred feet of heaving shale hole thus messed-up and water-soaked, further progress even with silicate mud becomes an expensive, nerve-racking, and often questionable problem.

It is a good plan at this stage to spend a few days in overhauling the equipment and making any needed changes in the surface mud-handling system. This can usually be done while the silicate mud is being prepared.

Field Equipment for Handling Protective Silicate Mud

The relatively higher cost of silicated mud justifies more care in its conservation than the muds used in most deep-drilling practice. It has been found profitable to install catch basins underneath the derrick floor to salvage the mud released from pipe sections as removed from the hole. It is important to avoid unnecessary dilution with water. Shaker screen, settling ditch, and storage pits should be covered to exclude rain. In one case, the conventional unlined earthen mud pits have been replaced with steel tanks to avoid earth contamination and seepage losses. It is usually more economical, however, to use rectangular vertical-sided pits lined with planking backed with tamped clayey earth.

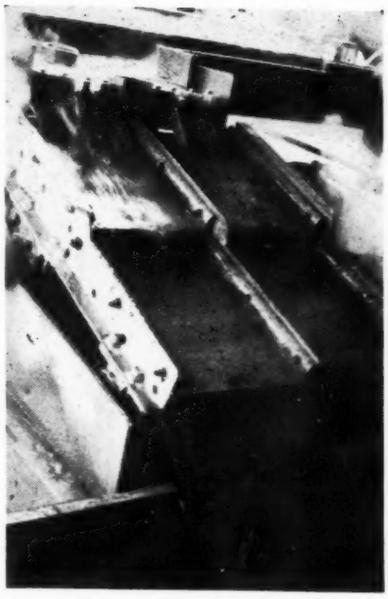


Fig. 8. Shaker screen removing bit cuttings from the mud

The fast gel rate of silicate mud requires that more than usual pains be taken in the removal of gas and the small rock particles that pass the screens. Quite satisfactory results have been obtained through the use of a baffled mud ditch 160 ft. long and 2 ft. wide, provided with a 3-ft. fall, and a set of submerged mud guns in the suction pit. One company has had success with a degasser evacuated by a steam jet. Some work has been done with a continuous centrifuge for removing the fine particles. Although these machines are to be considered as auxiliary, they are no doubt useful.

A typical good surface mud-system layout is shown in horizontal projection in Fig. 7. In normal drilling operation the mud returning from the hole flows over the two shale-shaker screens (Fig. 8), where the coarse rock particles are removed, down the baffled mud trough or ditch for partial removal of gas and sand, into the mixing pit, and by overflow into the suction pit. In each tank the mud is kept in motion by mud guns to prevent gelation and to release more gas and sand. From the suction tank the mud is picked up by the circulating pumps and pumped down the drill pipe to the bit, whence it carries its load of cuttings to the surface. Make-up materials are mixed with a stream of mud at the materials storage shed using a Halliburton-type jet mixer. On the job illustrated a vacuum gas separator having a hydraulic leg was used and a small stream of mud continuously circulated from the mixing pit through it for degassing and then to the suction pit. Other details of the layout are apparent from the drawing. Fig. 9 is a photograph showing part of the mud system on another location.

Preparation of the Mud

The formulation of the silicate mud presents a different problem on each well. The object in every case, however, is to achieve at minimum cost a volume of mud having the desired characteristics. It is usually possible to salvage a large portion of the valuable clays and weighting materials from the discarded water mud. The present procedure is as follows:

A series of mixtures is prepared from the mud on hand, the chemicals required, and water to give the desired concentrations in the aqueous phase. These experimental muds are then measured before and after 24 hours' heating at bottom-hole temperature. This permits evaluation of the unknown constituents in the mud and a determination of the amount of the old mud that can be used. Other series of tests reveal the quantities of other materials that must be added to attain the desired properties.

In a typical case the following materials were used at the well:

	Weight percent
Old water mud	37.1
Water	28.0
Silicate of soda (anhydrous basis)	22.2
Sodium chloride	5.1
Weighting material	7.5
Bentonite	0.1

and yielded a mud having the following characteristics:

Weight	13.1 lb. per gal.
Viscosity	38.5 centipoises
Gel strength	5.0 gm.
Filter test	8.5 ml. in 24 hr.

Balanced

A drill collar must have many qualities, all present in carefully balanced proportions, in order to give long, safe, economical service. Scientifically prescribed, accurately controlled treatment of the steel produces a balance of physical properties that insures great strength, high resistance to shock and fatigue, and good wearing qualities. An accurately centered circulation hole of uniform diameter promotes balanced rotation that saves your drill pipe—aids in drilling straighter hole. To be sure that you get the right balance between cost and dependable service, specify

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The silicate mud is made by measuring the old mud into the mixing pit and then adding the water at the Halliburton mixer. The silicate, salt, bentonite, and weighting materials are then added successively and the mud circulated until the soluble constituents are dissolved. This new mud is then circulated in the hole or otherwise heated to develop its full gel strength. Displacement of the water mud in the hole will result in the removal of the filter cake from the wall of any uncased hole and an allowance must be made for this material when formulating the silicate mud.

Drilling Practice

The use of silicate mud requires no departure from conventional drilling practice except in a few details. Protective silicate mud, if properly controlled, will neither build a thick filter cake nor permit the hole to constrict by swelling of the shale, hence it is unnecessary to carry a reamer on the drilling string. It is wise to keep always in mind that the shale is protected from disintegration whether in the hole wall or suspended in the mud. Shale particles do not break up in the mud stream. (Fig. 10.) As large clearances as possible should, therefore, be allowed between the drill pipe and set casing with special attention to avoid close clearances at tool joints, pipe protectors, back-off joints, etc. Bits are preferably of the open type, a fish-tail being preferable to a three-way, as the non-disintegration of the shale gives a little more trouble with balling-up. Especial care must be taken to avoid swabbing of the hole.

General

Protective silicate mud differs in many ways from a straight water-vehicle mud. Many unpredicted problems have been brought to light, each in its turn requiring prompt attention. Their occurrence has required the constant attendance on location of a specially trained chemical engineer, and it is doubted if this service can be eliminated.

One of the writers returned to a drilling job from lunch one day to learn of plans to pump a volume of Portland cement slurry to cement the bottom of a string of casing, using silicated mud in direct contact, immediately before and behind the cement. It took less than half an hour to convince the superintendent by demonstration that the contact with silicate of soda would result in a quick and disastrous setting of the cement. The problem was solved by interspersing a slug of water immediately before and behind the cement. This and subsequent cement jobs have been successfully completed by using this technique.

Many of the operations around a drilling job are of such a nature that members of the crew are sometimes showered or otherwise wet with mud. Protective silicate mud will irritate the skin if left in contact for any great length of time, and particularly where subjected to rubbing by the clothing such as under neck- and wrist-bands, belts, and shoe tops. The hands are relatively unaffected. Silicate introduced into the eye is a very painful experience. No serious effect has ever been reported, but a workman may have a rather sore eye for a few days unless the alkali is fairly promptly washed out with copious quantities of water.

Oil men feared for a long time that the use of silicate mud would permanently seal any oil sands drilled with it. This fear has been proved groundless in the light of established and continued production from wells drilled with this mud.

The Schlumberger method of electrically surveying a bore hole to locate any possible productive sands is widely used. The method depends upon differences in the electrical resistance of various strata. It has been feared that silicate mud would prove troublesome because of its high electrical conductivity, and water mud was replaced in one hole before making such a survey. A recent survey in a hole still filled with silicate mud clearly indicated an oil sand that was not logged in the drilling, and the well is now a good producer from this level.

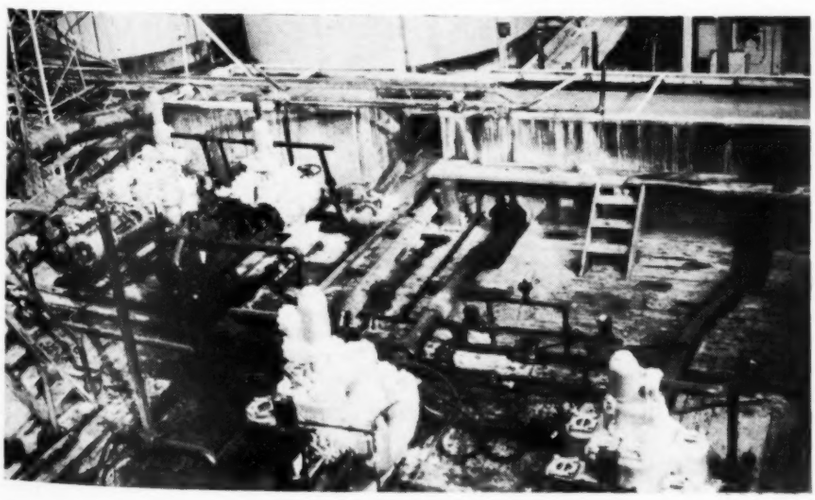
Silicate mud is remarkable in its resistance to change by the materials drilled. Salt is the bane of the engineer dealing with water mud because of its strong flocculating effect. Drilling through anhydrite or gypsum is likewise troublesome. In contradistinction to the sensitivity of water mud, hundreds of feet of solid salt have been drilled with silicate mud and there was no appreciable change in its characteristics.

When drilling shales and particularly the softer ones, a water mud increases in viscosity more or less rapidly owing to the hydration and dispersion of the clay-like material. This effect can be counteracted to a degree by the addition of peptizing agents and other chemicals in small amounts, but, in heaving shales, thinning with water invariably becomes necessary. Protective silicate mud will not permit the dispersion of the shale cuttings. It is seldom necessary to add liquid to silicate mud in greater quantity than is required to make up for mechanical losses and the increased volume required to fill the new hole drilled. The same batch of silicate mud has been used in drilling the heaving shale sections in four wells, including the drilling of several hundred feet of salt and anhydrite and the placing of several cement plugs. In each case the mud has been recovered from the hole after completion. The final total increase in volume over that needed for operating was less than 1000 bbl.

There is an indirect economy in the use of silicate drilling mud that has not as yet been fully evaluated. Owing to the small amount of liquid addition required to control viscosity, the

(Continued on Page 110)

Fig. 9. A view showing part of a mud-circulating system



The Derrick Man sights the tang... tightens the clamp for an Orienta... vey shot made on drill pipe.

The... book...

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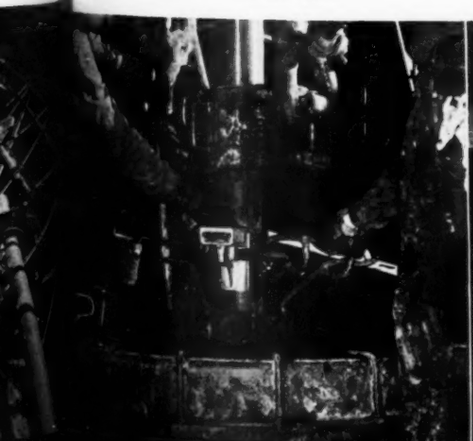
The slips are set while another stand of pipe is hooked on. The clamp, now at the floor level, has rotated with the pipe.



The Floor Man sights the target through the telescope.

Reading the vernier to determine pipe rotation. From these accurate readings, direction and inclination of the hole from the surface to the bottom are calculated.

(Continued from Page 107)

weighting material requirement is virtually limited to the volume of mud needed for drilling. In contrast to this, the necessary water dilution to control the viscosity of water mud requires, in deep wells, the addition of corresponding quantities of weighting material. The investment thus made in expensive weighted mud in excess of what can be utilized has been known to run into tens of thousands of dollars on some wells.

The protective silicate-mud technique here reviewed provides an opportunity to avoid hydrous alteration of heaving shale during and after drilling. It cannot be expected to correct the damage done by unwisely drilling part of the sensitive shale with water mud, nor to escape the penalty for mechanical mistakes in drilling. Properly and intelligently applied, the method can be depended upon to prevent heaving caused by hydrous disintegration.

Fig. 10. Bit cuttings of heaving shale drilled with protective silicate mud. The sharp preservation of bit marks and pressure folds show that no hydrous alteration has occurred

Acknowledgment

The progress herein reported is the work of many people with whom the authors have had the privilege of cooperating. Grateful acknowledgment is especially made to William V. Vietti, who early sponsored and helped carry on the work, to E. W. Louden, Orien Van Dyke, and Harry L. Bolton, who by their efforts have made substantial contributions, and to the several oil companies whose patient money has made the work possible.

Petroleum Production in Rumania, Germany, and Austria

THE Rumanian petroleum industry is at a critical stage. The output of the present oil fields is diminishing, even though more drilling is being done and the future depends upon the development of new productive areas, says a report made by Charles Will Wright, foreign mineral specialist, to the U. S. Bureau of Mines. Government legislation and taxation have discouraged new drilling operations by outside companies, and the exporting companies are having serious difficulties in liquidating the large sums to their credit for exports at the National Bank of Rumania. The decrease in production from 8,710,000 metric tons in 1936 to 7,180,000 tons during 1937, and the further decline in 1938 is causing apprehension as to the future of Rumania. Noteworthy is a reduction of 25 percent in the exports of petroleum products during the first half of 1938, compared with those during the first half of 1937, although consumption in Rumania during the first half of 1938 increased 9 percent. Total output of crude petroleum to November 1, 1938, was 5,500,000 tons, a decrease of 510,000 over the first ten months of 1937.

In 1938 a new petroleum exploration and exploitation company called Sonapetrol, largely owned and controlled by the Rumanian State, was organized to undertake intensive explorations in the regions Sacele-Zorlesti of Oltenia, Soveja of Putna, and Tazlan Bacan and Radanti in Bucovina.

In September, 1938, a new Anglo-Rumanian Clearing Agreement was concluded, which should stimulate Rumanian oil exports to the United Kingdom and regulate payments. This has been followed by proposed modifications of the Mining Law, and the granting on October 29, 1938, of a joint concession covering an area of 50,000 hectares to be explored by the Rumanian company Credit Minier and the Unirea S.A.R., which is allied to British interests. It thus appears that Rumania is to adopt a more liberal attitude toward foreign operators in granting concessions and to devise ways of affording some relief from the onerous foreign currency restrictions as well as a reduction in the present heavy local taxation.

An arrangement has recently been made with Italy for a supply of motor vessels in exchange for 60 percent payment in Rumanian oil and 40 percent in cash.

Production of crude oil in Germany, 80 percent of which is from the Nienhagen field near Hannover, was about 450,000 tons in 1937. It is estimated that the output in 1938 will be 550,000 tons. To this must be added the Austrian production, which was 33,000 tons in 1937 and is estimated at 70,000 tons for 1938.

The increased output in Germany will come from the new field at Reitdebrook where 12 drill holes 1600 to 1800 meters in depth have been successful in finding oil along an anticline just south of Hamburg. These explorations have been carried out on a 50/50 basis between the Prussian State and the Socony-Vacuum Oil Company.

These wells are kept partly closed awaiting construction of plants to process the production. At present the oil is sent to refineries at Bremen. An output of 100,000 tons a year is expected from this field.

New wells have also been opened just east of the Nienhagen field, and in Baden near Worms. Increased output is in prospect at the Heide field, but Volkenroda and Fallstein are virtually exhausted. The others are maintaining production.

The production of motor fuels from domestic sources in 1937 in metric tons was as follows: Synthetic gasoline, 1,100,000; benzol, 450,000; alcohol, 180,000; gasoline from domestic crude oil, 45,000; and distillate from brown coal tar, 30,000; total, 1,805,000.

The production of domestic motor fuels in 1938 may reach 1,900,000 tons. In 1939 it should total 2,500,000 tons for light motor fuel, or about 50 percent of normal consumption requirements.

It is stated that refinery capacities for imported oil have not and will not be increased; and that Germany's increased requirements must be produced from domestic sources. Imports of crude oil have been increased from 538,000 metric tons in 1936 to 722,000 tons in 1937. Also Germany's net imports of petroleum products excluding crude oil have averaged about 3,000,000 tons in 1936 and 1937.

The total apparent consumption of petroleum products and motor fuels in Germany is about 5,600,000 tons and that of former Austria about 400,000 tons.

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Fig. 5510—A sturdy, inexpensive side-suction centrifugal pump for either belt or direct-driven installation. An efficient design in a low-price pump.

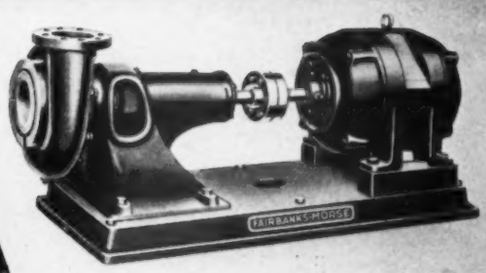

Fig. 5530—Ball-bearing design, rigid frame construction and special type packing seal are unusual features of this pump. F-M volume production makes possible a moderate price.

Fig. 5550—A Builtogether unit with pump and splashproof motor built on one shaft. Undivided responsibility with one guarantee is your assurance of satisfactory operation.

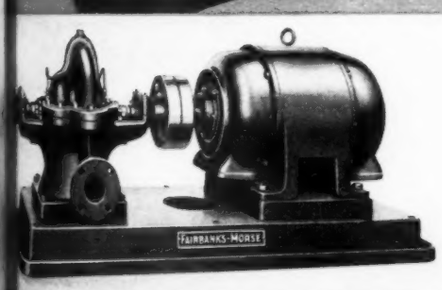

Fig. 5813—A centrifugal pump with split case design permitting entire rotary element with sealed ball-bearings to be easily removed. Features low maintenance and repair costs.

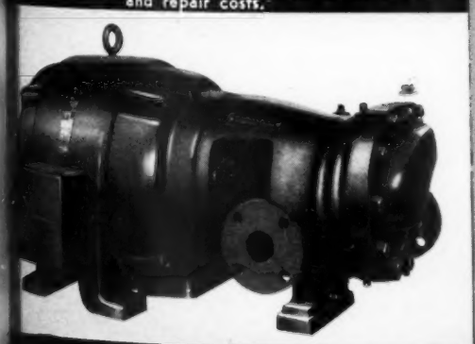

Fig. 5592—Builtogether design, two stage. Bronze fitted. Splashproof motor, ball bearings. Suitable for heads up to 600 feet.

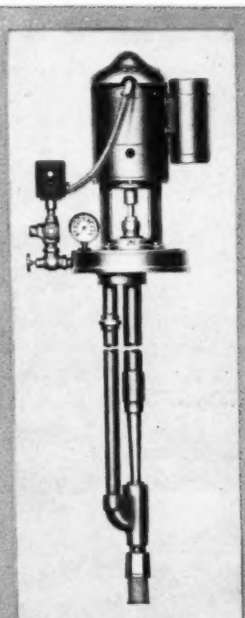

Fig. 6640—Centrifugal ejector pump features simple design and low maintenance costs. Suited for either deep or shallow wells and may be connected to a pressure system.

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Non-Catalytic Processes of Cracking Liquid Hydrocarbons

Effects of temperature, pressure, contact time, and nature of charging stock on products

By RAFAEL FUSSTEIG

AS known, the invention of the cracking system caused a great expansion of the oil refining industry, as it offered the possibility of artificial production of gasoline. The essential characteristic of this cracking process is the fact that always the light hydrocarbons combine with nascent hydrogen split from the second part of the molecule.

Because of this hydrogen migration, the second part of the split molecule loses large amounts of its hydrogen content, leading to the formation of unsaturated higher molecular hydrocarbons. The first part of the split molecule will burn completely, because enlarged with hydrogen, whereas the second part of the same split molecule burns more difficultly because of the great difference in rate of combustion of carbon and hydrogen.

Carbon in the free state burns with great difficulty, its ignition being possible only at high temperature. The necessary temperature can be attained by the combustion of hydrogen. For this reason the greater the hydrogen content in the hydrocarbon, the better the combustion and the lower the temperature of ignition. If a hydrocarbon does not contain a sufficient quantity of hydrogen it will not burn completely, but will form soot. Furthermore, the fractions of crude oils are successively richer in carbon and poorer in hydrogen. This is the reason that the higher molecular fractions burn with more difficulty than the lower molecular ones. Table 1 shows the decrease of hydrogen and increase of carbon in the fractions of a crude.

TABLE 1

Fraction	Carbon content, percent	Hydrogen content, percent
Gasoline	84.8	15.2
Lubricating oil	86.2	13.8
Cylinder stock	87.3	12.7
Asphalt	88.9	11.1

The cracking operation causes not only the splitting of the hydrocarbon molecules but also a migration of the hydrogen atoms into the smaller parts of the split molecules. In other words, this hydrogen migration occurs in such manner that the hydrogen content of the smaller part is increased to about 15 percent, thereby forming gasoline.

As the crude oil contains about 14 percent hydrogen, the larger part of the split molecule loses hydrogen, resulting in the condensation of this part into higher molecular hydrocarbons such as tar and coke. About 50 percent gasoline is produced by means of this splitting and migration process. If, however, a heavy gas oil containing about 14 percent hydrogen and 86 percent carbon is submitted to the cracking process, a yield of about 60 percent gasoline is obtained, this gasoline containing about 84.8 percent carbon and 15.2 percent hydrogen.

Of course, the residuum of this process is poorer in hydrogen, containing 87.5 percent carbon and 12.5 percent hydrogen. A migration of about 1.5 kg. hydrogen is necessary to transform 100 kg. of a crude oil into about 50 kg. of gasoline. In other words, an interior rearrangement takes place in the cracking process, in which about 1.5 kg. hydrogen causes the formation of gasoline.

A quantity of gaseous hydrocarbons rich in hydrogen, such as methane, ethane, propane, butane, ethylene, propene, and butene, is split from the hydrocarbon molecule, however, this gas leaving the reaction chamber without further reaction. This represents a great loss in the yield of gasoline, as with increase in gas production the quantity of higher molecular hydrocarbons poor in hydrogen increases. The cracking process should therefore be so controlled that the greatest possible quantity of hydrogen is able to migrate to the fraction that forms gasoline.

Temperature and contact time are the most important factors in the cracking processes, as they determine the yield of gasoline and coke. Moreover, the chemical nature of the starting material also plays an important role, as the hydrogen content of the crude also affects the yield of gasoline

Rafael Fussteig is professor of petroleum technology in the École Supérieure Technique et Commerciale de Paris, Paris, France. He has contributed numerous articles to *The Petroleum Engineer* on such subjects as selective solvent extraction, the manufacture of anti-knock gasoline, bleaching clay, extraction of paraffin wax from crude oil, the synthesis of lubricating oil by polymerization of gaseous hydrocarbons, and the importance of pyrolysis in the refining of lower hydrocarbons. The accompanying article discusses a phase of the last-mentioned subject.

TABLE 2

Cracking temperature, deg. cent.	Gasoline yield				
	10 percent	20 percent	30 percent	40 percent	50 percent
400	180 min.	360 min.	720 min.	1800 min.	3600 min.
425	30 min.	60 min.	120 min.	300 min.	600 min.
450	5 min.	10 min.	20 min.	50 min.	120 min.
475	1 min.	2 min.	4 min.	10 min.	20 min.
500	10 sec.	20 sec.	40 sec.	2 min.	4 min.

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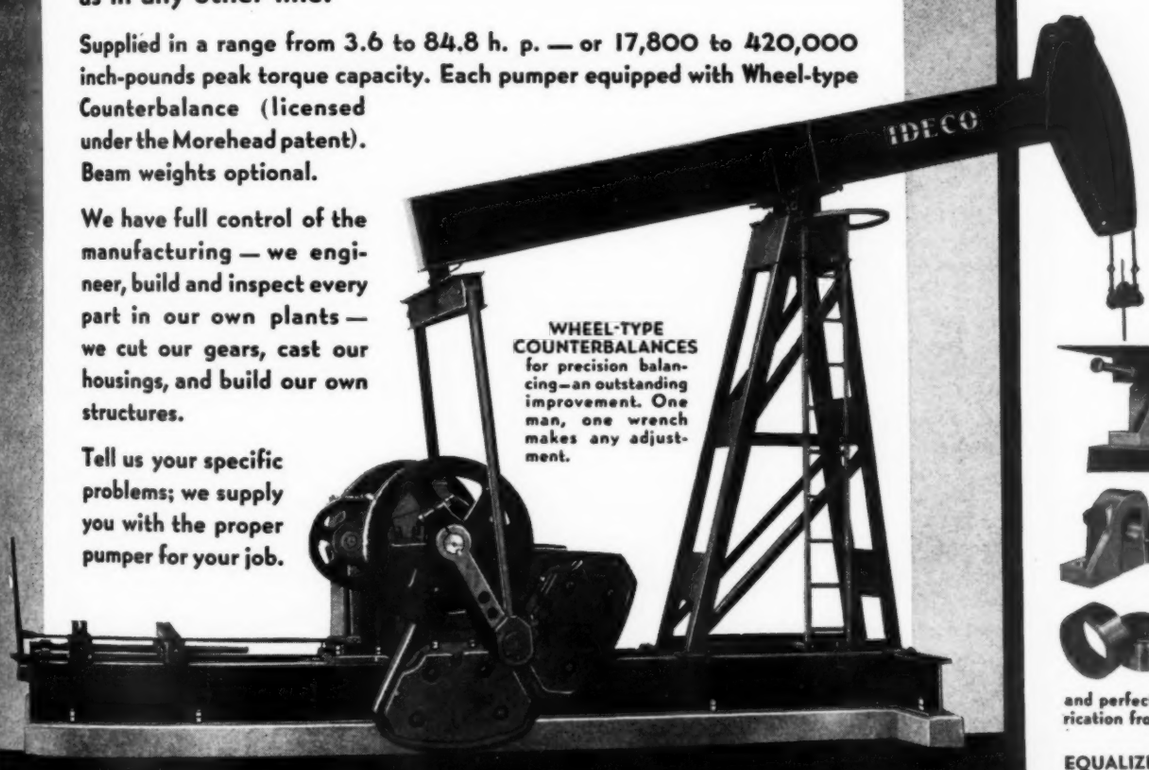

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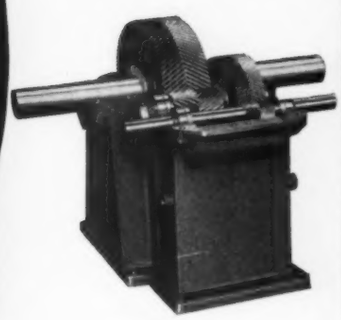

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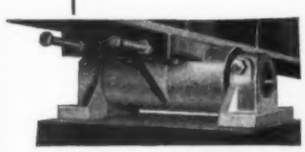

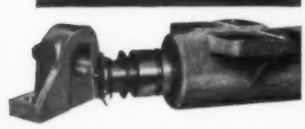

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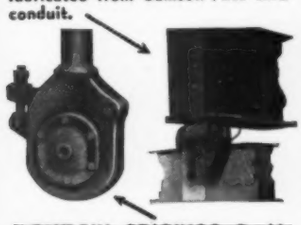

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and coke. Lower molecular hydrocarbons having low boiling points give under equal conditions a higher yield of gasoline and a lower deposition of coke than higher molecular compounds having high boiling points.

With the increase of specific gravity of the starting material, however, the rate of decomposition decreases. For instance, kerosene and gas oil decompose more slowly than heavier oils. Therefore with increase of specific gravity the contact time must decrease. Kerosene, therefore, requires a longer contact time than gas oil. Sachanen gives the following relationship between temperature and contact time.

Table 2 shows that a minimum yield of ten percent gasoline is obtained at the temperature of 400 deg. cent. and at a contact time of 180 minutes, whereas a maximum yield of 50 percent gasoline is obtained at the temperature of 500 deg. cent. and contact time of four minutes. In practice the yield of the first throughput should amount to 20 or 25 percent by weight, as higher gasoline yields cause excessive formation of coke, resulting in frequent interruption in operation.

Of course, the formation of coke depends to a great degree on the boiling range and on the chemical nature of the product. Higher boiling fractions of the same crude oil show a greater deposition of coke than the lower boiling ones. If the products have the same boiling ranges, the specific gravity influences the yield of coke, that is, the higher the specific gravity the greater the deposition of coke.

The explanation of this phenomenon lies in the coherence to the content of polycyclic aromatic hydrocarbons of higher specific gravities, these hydrocarbons having the tendency to form coke. Of two starting materials of the same boiling range, that having a higher content of polycyclic aromatics will cause a greater deposition of coke.

As mentioned, only 20 to 25 percent gasoline should be produced from the first throughput to avoid excessive formation of coke. In practice this operation is carried out in such a manner that the heavy coke-forming components and gasoline are removed at the moment that coke formation and decomposition of the gasoline are observed. In the modern cracking units the pressure distillates and the residuum are continuously removed from the reaction chamber while the starting material mixed with the secondary products is directed to the reaction chamber.

In other words, a part of the unattacked material must be recycled. Sachanen, studying the recycling problem, has carried out a cracking experiment on a straight-run gas oil boiling between 200 and 350 deg. centigrade. He cracked this gas oil in an autoclave until coke began to form. The gasoline and the gas-oil fraction were separated from the residuum. This gas-oil fraction was submitted to a second cracking process until formation of coke was observed. The gas-oil fraction remaining from this process was submitted to a third cracking, etc. The results of these experiments are shown in Table 3.

The specific gravity of the gas oil increased with repetition of the cracking process. This is correlated with the increase of the content of polycyclic aromatics, and with the phenomenon that in cracking without deposition of coke the yield of gasoline decreases. Each subsequent recycle of the starting material shows a decrease of the gasoline yield and coke formation. In other words, at each subsequent recycle the oil loses cracking capacity, that is, it loses its ability to give maximum gasoline yield and minimum coke deposition on decomposition. Sydnor and Petterson[1] found that the ratio of the cracking residuum yield to the gasoline yield of an American oil changed its value during cracking as follows:

For the first process	0.18
For the second process	0.38
For the third process	0.51
For the fourth process	0.71

Recycling must be regarded as the very important factor that causes the maximum yield of gasoline and the minimum coke formation. In that manner it is possible to obtain a gasoline yield of 60 percent without noticeable formation of coke. Such gasoline yields can be increased by repeated cracking. Of course, the maximum gasoline yield in the recycling process depends to a great degree upon the nature of the products. Crudes of asphaltic base give a smaller yield than those of paraffinic base. It is evident that the lighter residuums show a somewhat smaller gasoline yield than the distillates of the same specific gravity. The reason for this is the difference in the quantity of hydrogen. As far as heavy residuums are concerned, they will not yield a large quantity of gasoline without formation of coke, as these hydrocarbons are poor in hydrogen, hence the easy deposition of coke.

As mentioned, the starting material is pumped to the cracking unit, together with the recycling material to be split. In modern cracking units the starting material is mixed with the recycling oil before the cracking process, being then subjected to the same conditions of temperature and pressure. The recycling ratio, the proportion of the mixture to the starting material, plays a very important part in this process. The higher the recycling ratio the greater the tendency of the oil to form coke. Ordinarily the recycling ratio varies between two and five, being dependent on the characteristics of the starting material and on the gasoline yield.

Excessive recycling ratios present certain disadvantages from the economic standpoint. As the quantity of the circulating mixture increases the required capacity of the cracking units and the consumption of heat increase. It should be mentioned that the straight-run material shows a higher cracking velocity than the cracking oil. Therefore, it has been proposed[2] that two oils be treated under different conditions in different cracking units.

According to this proposal the straight-run oil is cracked in a series of cracking units, using different temperatures and contact times. The recycling oil from the first unit is pumped to the second unit, the recycling oil from this unit to the third unit, etc. Of course, each of these units requires different working conditions.

As far as pressure is concerned, many investigators maintain that it has no influence on the yield of gasoline nor on the cracking velocity during the process. Others insist that the pressure determines the type of decomposition reactions, that is, it decides the point at which the hydrocarbon is split. It must be admitted, however, that the pressure plays an important part in the heat transmission during the pyrolysis, which is the

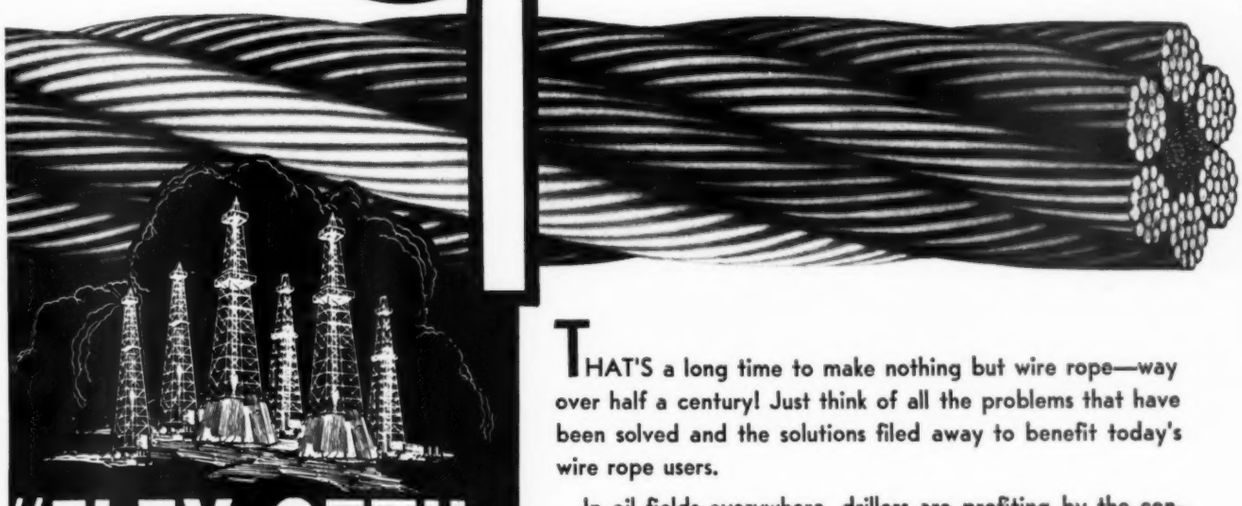
TABLE 3

Gas oil	Spec. grav. at 15 deg. cent.	Gasoline yield before the beginning of coke formation, percent
Straight-run	0.830	30
After the first cracking	0.850	24
After the second cracking	0.869	21
After the third cracking	0.898	18
After the fourth cracking	0.924	12
After the fifth cracking	0.957	10
After the sixth cracking	1.029	4

[1]Ind. Eng. Chem. 1930, p. 1237.

[2]Sachanen and Tilichejew; Oil and Gas Journal, December 15, 1929.

63 YEARS



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reason that a high pressure is used in the pyrolysis processes. Excessive pressures possess economic disadvantages, as the price of the apparatus is excessive. Low pressures are also inconvenient as too great a volume of vapors causes a great velocity in the tube-still and in consequence more heating surface must be used.

The choice of the pressure depends primarily on the boiling range of the starting material. The reason for this is that the lower boiling products such as kerosene or gas oil require a higher pressure than the higher boiling heavy oils or residuums. That is the reason that the cracking systems that produce gasoline from kerosene or light gas oil use a considerably higher pressure than those producing from heavier fractions.

Moreover, the pressure increases the boiling points of the hydrocarbons during the pyrolysis process, so that the contact time can be increased also. Pressure itself is not able to increase the yield of gasoline. Therefore, if we intend to produce a higher gasoline yield, the cracking residuum also must be subjected to pyrolysis. As this residuum is poor in hydrogen content, it is evident that its pyrolysis must lead to formation of a large quantity of coke.

It is therefore convenient to distill this cracking residuum, for separation of the distillates from the residuum of asphalt-like compounds poor in hydrogen content. This operation possesses the economic advantage that the coke-forming higher molecular hydrocarbons are removed before the stock is submitted to the cracking process. Moreover, these higher molecular hydrocarbons when cracked in the reaction chamber with the distillates consume hydrogen atoms from the fractionated distillates, thereby decreasing the yield of gasoline.

The distillate from the cracking residuum yields a greater gasoline production than the cracking residuum itself. On the other hand the pyrolysis of hydrocarbons leads to a splitting of permanent gases from the hydrocarbon nucleus. This phenomenon is correlated with the formation of higher molecular hydrocarbons. The greater the yield of higher molecular hydrocarbons in the process the greater the yield of permanent gases. Of course, the contact time plays an important part. If the optimum contact time is exceeded, the gasoline yield decreases and the formation of permanent gases increases.

In other words, each starting material possesses its own optimum contact time, which should not be exceeded. Therefore the starting material should be cracked in such manner that 20 to 25 percent gasoline is produced. The gasoline formed during the cracking process should be removed from the reaction chamber. Thus the gasoline yield can be increased, especially when the recycling oils are cracked under proper conditions. In practice two throughputs of recycling oils are sufficient for a satisfactory gasoline yield.

As mentioned, the remaining cracking residuum in this process, the so-called residuum process, also must be submitted to pyrolysis. This cracking residuum, however, can be cracked by the so-called non-residuum process. This operation produces gas, gasoline, and coke. In other words, this residuum is cracked in the reaction chamber for such a length of time that no liquid residuum remains.

The formation of coke and the gasoline yield in the non-residuum process depend to a large degree on the nature of the starting material, its composition, and boiling range, these being the most important factors in this process. Starting materials of high boiling points and specific gravities give more coke and less gasoline than those of low boiling points and specific gravities. The non-residuum process gives a smaller gasoline yield than the residuum process, the starting material being the same. The non-residuum process, however, possesses a distinct economic advantage: the cracking of the straight-run material and the cracking of the residuum is united in one process.

The above-mentioned processes are performed on materials in the liquid phase. It has been stated by many investigators that the gasoline made by this process contains certain hydrocarbons that reduce its anti-knock properties and does not contain sufficient amounts of anti-knock hydrocarbons. Therefore many petroleum experts have been seeking a method for rearranging the gasoline into a motor fuel of high anti-knock properties.

The invention of vapor-phase cracking was a new step in the development of the cracking industry. In this process the starting oil is first evaporated, then submitted for a very short time to a cracking process at a high temperature (above 500 deg. cent.) and low pressure (0.5 to 2 atmospheres). The resulting product is a gasoline of very high anti-knock properties, because olefinic and cyclic hydrocarbons are formed during this vapor-phase process. In other words, not only a splitting of the hydrocarbon molecule into smaller parcels takes place but also a reconstruction and isomerization of the gasoline-like hydrocarbons occurs in the vapor-phase reactions, transforming the inferior gasoline-like hydrocarbons into gasoline of very high anti-knock value.

Investigators have stated that this process could be employed in the improvement of cracked and straight-run gasolines. Different patents have proposed the reforming of the inferior gasolines. This reforming operation is performed in such manner that the gasoline vapors leaving the reaction chamber are directed once more to a pipe-still, where they are heated to the required temperature before being submitted to a cracking reaction in the second reaction room of a liquid-phase operation. Of course, a suitable pressure must be used in this process.

Thus, the gasoline vapors are reconstructed in the second reaction chamber to a gasoline of better qualities. This reforming process, however, yields a smaller quantity of gasoline than the old liquid-phase systems, because the rearrangement of the inferior gasolines causes a splitting of gas and residuum from the hydrocarbon molecule. For example, 100 parts of a straight-run gasoline submitted to a reforming process yields about five parts of residuum and about ten parts of gas, so that 85 parts of gasoline of higher qualities will be produced. The greater the octane number in the reformed gasoline the smaller the gasoline yield, of course.

The reforming process is very flexible, that is, widely different operating conditions can be used, these determining the yield and the octane number of the gasoline. For example, gasoline vapors from the first reaction room of an octane number 32 submitted to the reforming process give 90 percent gasoline of an octane number 65, and only 75 percent gasoline of 80 octane number. This reforming process causes no coke formation because of the abundance of hydrogen atoms. Therefore no recycling is necessary in the reforming process, and a smaller reaction chamber can be used, supplemented by reaction tubes, the so-called soaking tubes. Such a reformed gasoline would contain about 80 percent cyclic compounds and about 10 percent olefins, these hydrocarbons giving the gasoline a high octane number.

Besides the manufacture of the gasoline, the cracking process is also used to break the viscosity of heavy and highly viscous oils. This application produces little or no gasoline, as the pyrolysis proceeds only to the first reactions. In the first phase of the pyrolysis, only the heavy and viscous components of the starting material are split, so that kerosene and gas oil are formed, thus lowering the visco-

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ity of the stock, without appreciably changing the flash point. This process, however, must be strictly controlled, to avoid any formation of coke, as coke reduces the qualities of the oils obtained.

The work of many investigators has established certain principles that have contributed directly to the development of the modern cracking process, one of the most important being the selection of starting oils according to comparatively narrow boiling range and the segregation of stocks according to refractivity. As mentioned, greater gasoline yield of higher octane number, and lower recycling ratio are obtained when the straight-run and recycling materials are cracked in separate reaction rooms rather than as a mixture in a single chamber.

This is also true when a combined cracking material is segregated according to the boiling range. When the combined stock is cracked in one reaction room the pressure and temperature must be an average of the optimum conditions for each of the two stocks. This results in use of conditions for the mixture that are too mild for the light fractions and too severe for the heavy fractions. Consequently, the light oils are under-cracked, giving low octane numbers, and the heavy oils are over-cracked, forming coke.

The segregation of stocks according to refractivity shows very important advantages, the refractivity being a function of original source and degree of previous cracking. Tarassow and Seledzniejew[3] showed that under equal operating conditions the gasoline yield varies inversely with the refractivity of the charging stock. According to their practical observations these investigators came to the conclusion that recycle gas oil can be submitted to higher temperatures than straight-run oil of the same boiling range.

If these two materials were cracked in a mixture the operating conditions would be limited by the tendency of the straight-run material to form coke, and the recycle oil would be under-cracked. When these two materials are cracked separately at their optimum operating conditions, larger yields of higher octane gasoline, and lower recycle ratios will result. This improved performance is obtained by operating each reaction room at high crack per pass, or volume percent gasoline yield on heater charge. The lighter the cracking oil the higher the allowable conversion per pass.

According to Smoley, Mekler, and Schutte[4] the range of crack per pass obtained in practice without excessive coke formation varies with the cracking stock characteristics as follows:

1. Viscosity breaker stocks three to ten percent.

2. Heavy virgin and heavy refractory stocks 10 to 18 percent.

3. Light virgin and light refractory stocks 14 to 30 percent.

To obtain the desired crack per pass the stock must be subjected to a definite rate of cracking, which is determined by the soaking time and temperature allowed in the heater. According to these three investigators, the ratio of total cracking heater feed to fresh cracking stock, or the overall combined feed ratio, is determined by the crack per pass obtained in several heaters of a combination cracking unit. This ratio usually ranges between 2:1 and 4.5:1, depending on the character of the stock, the degree of selectivity, and the method of processing. As a rule the heavier the fresh feed stock the higher the combined free ratio. The theoretical unit that would take advantage of selective cracking to the fullest extent is one in which all stocks are separated according to both refractivity and boiling range. Practically, there is an economic limit to the number of selective reaction rooms—now selection coils — that are used. This depends primarily on the type of the original starting material, the products required, and the size of the unit.

[3]Nephtian. Chozj, 1932, p. 177.
[4]Presented before the World Petroleum Congress, 1937, Paris.

The Use of Bauxite in Oil Refining

EXPERIMENTS begun in 1937 on the use of bauxite instead of Fuller's earth for decolorizing lubricating oils by percolation methods were extended in 1938 by the U. S. Bureau of Mines, and by the close of last year ten or more refineries were using the new process exclusively, says a report by Paul M. Tyler of the Bureau. Bauxite seems to be applicable to oils of the paraffinic type and to those that can be made paraffinic, but does not work so well, apparently, on asphaltic or naphthenic oils. For this reason, although it already is used extensively in Pennsylvania, and is in demand in the Mid-Continent area, it has not been employed in Texas, California, or the coastal area. Compared with a good grade of natural Fuller's earth, bauxite is only about half as efficient by weight; but, because its density is 80 percent greater, it is 90 percent as efficient by volume. The main advantage of bauxite is that it can be revivified indefinitely, whereas Fuller's earth loses its efficiency and must be discarded after being revivified 20 times. The shrinkage at each burning is about 1½ percent, so even bauxite must be renewed; but inasmuch as its life is about 67 cycles, its higher cost is more than justified if the nature of the oils makes it applicable. Delivered at Pennsylvania refineries in 1938, the prepared bauxite granules cost $38.85 a short ton, as against $21.97 for Fuller's earth of good quality.

The new product is sponsored by the Porocel Corporation, 260 South Broad Street, Philadelphia, Pennsylvania, which is jointly controlled by the Attapulgus Clay Company, an Atlantic Refining Company affiliate, and the American Cyanamid Company. A new plant is being built at Berger, about seven miles south of Little Rock, Arkansas, and suitable steps have been taken to assure an adequate supply of raw ore. The Attapulgus company is also one of the largest producers of natural Fuller's earth and about two years ago engaged in the production of activated earth under a joint arrangement with the Filtrol Company.

The other producer of bauxite for oil refining, Max B. Miller and Company, also is a producer of natural Fuller's earth as well as of acid-sprayed earth. This plant is at West Bauxite, Arkansas. The product is given one burn and supplied in 20/60 and 30/60 mesh grades in bulk or in 100-lb. bags. Prices f.o.b. Arkansas range from about $30 to $40 according to quality, quantity, and whether in bags or bulk. Freight to Pennsylvania refineries from Arkansas shipping points averages about $6 a ton.

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Fig. 940
New Jarco Roller
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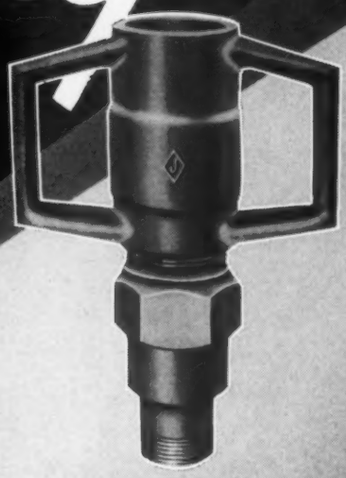
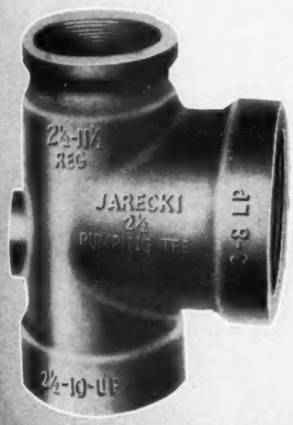


Fig. 934-K
Jarecki Erie
Improved Stuffing Box



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THE NEW JARCO ROLLER PULL ROD CARRIER has an oil reservoir, located within the wheel, which holds 1/6 pint; this is sufficient oil to last at least 6 months. From the reservoir, the oil feeds slowly through a porous bronze bushing to the shaft. Dust cannot reach bearing surface. Frame is of malleable iron.

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Construction of the 10-in. pipe line from Dammam to Ras Tanura, a distance of 43 miles. Pipe was hauled across the desert by tractors

Three wells are producing at Dammam Dome, others are being drilled, and exploratory work indicates excellent prospects of finding additional oil production

Technical Improvements in the Petroleum Industry of Saudi Arabia Accompanied by Cultural Advances*

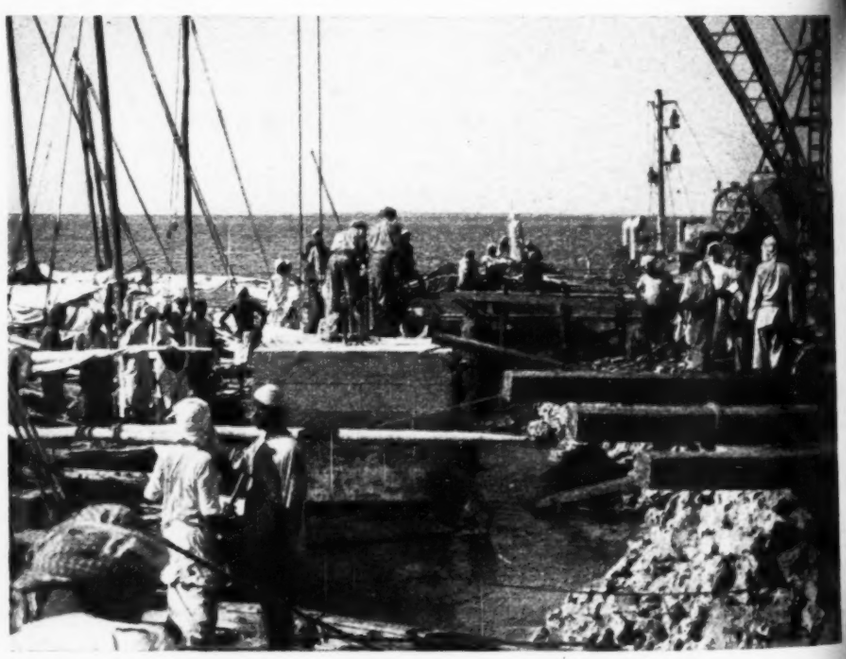
READERS may recall a brief report from the Dammam oil field, in eastern Saudi Arabia, that the California Arabian Standard Oil Company had brought in Well No. 2, which had a large potential production of high-gravity oil. Twice in the last two and one-half years this well has demonstrated the productivity of Dammam —once at a depth of 2152 ft., and now in the 4700-ft. zone. Other encouraging prospects are making their appearance as work proceeds in Saudi Arabia.

The company's concession covers an area somewhat larger than the entire state of California and has not yet been fully explored, but to the extent that it has, there seem excellent possibilities of finding other oil structures.

Three wells have been drilled at Dammam Dome — Nos. 2, 4, and 7. The last was completed in March, 1938, and the first two in October. Two more wells are being drilled at present and it is planned to have five strings of tools working by February. Dammam Dome is at least as large as the structure on Bahrein Island, 20 miles from the mainland, where development work began in 1933. About 100 miles northwest of Dammam, at Abu Hadriya another well has just been begun.

Side by side with the successes of Saudi Arabia are its challenges, and high among these is the absence of most of the living, traveling, and recreational facilities that are taken for granted by readers back home. Wherever new work is to be done the company must first plan hotels, restaurants, private transportation, work transportation, food supply, water supply, power supply, and private homes. That is how the growing settlement of Dammam came to see the light of day in

*Written from an article on exploration in Saudi Arabia appearing in the *Standard Oil Bulletin*.



Construction activity at Ras Tanura, the new shipping terminal

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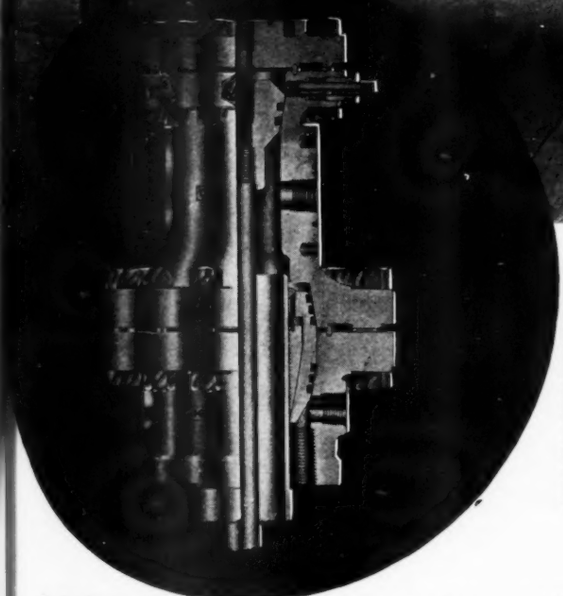

Left—Cross-section view of O-C-T type C-7X Slip Suspension Casing Head with type T-16 Tubing Head flanged above. Hanger encloses 3-segment slips, each of which is provided with an eye bolt that extends up through top of hanger. Eye bolts, which facilitate lowering hanger assembly to seat through preventer, are removed and the holes welded up when casing is suspended.

Right—Typical O-C-T Tree in the Shuler, Arkansas, field.

In the Shuler, Arkansas, field you'll see more than a sprinkling of O-C-T Christmas trees. One of the largest operators in the Mid-Continent buys them by the truckload, using the popular O-C-T type C-7X Slip Suspension Casing Head and type T-16 Tubing Head.

Using this equipment, the standard completion method is, briefly, as follows: Hole is drilled for the oil string which is set and cemented through oversize flanged blowout preventer equipment installed above the C-7X Casing Head body. The hanger, which encloses 3-segment slips, is lowered through the blowout preventer equipment to its seat in the casing head body to suspend the casing at any desired point. After removing the blowout preventer equipment, the last joint of casing is cut off slightly above the hanger and welded thereto. Then, with the type T-16 Tubing Head replacing the oversize flanged blowout preventer equipment, and with blowout preventer equipment installed above the tubing head, the well is drilled in and tubing is run and landed. Lock down screws are made up to hold the tubing hanger in the head, blowout preventer equipment is replaced by the top half of the Christmas tree, and the well is washed in.

Full particulars on the complete line of O-C-T assembled and tested Christmas trees, Casing Heads and Tubing Heads will be gladly furnished on request.

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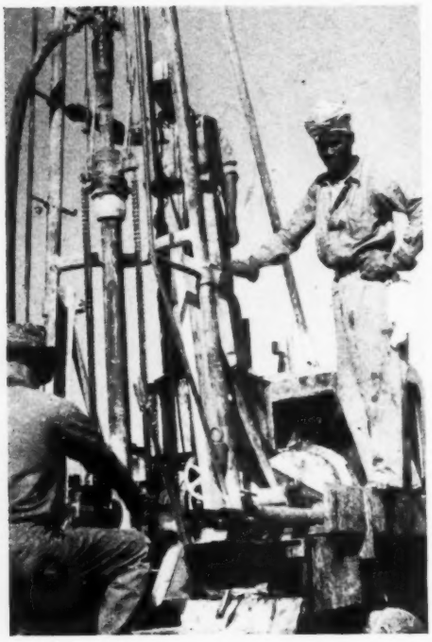

A geophysical crew

Saudi Arabia. It is both brain-child and accomplishment of the California Arabian Standard Oil Company.

First, it is functional—planned exactly to fit its job and its part of the world. Second, it keeps its people cool, comfortable, and rested between intervals of work and recreation on the desert.

Saudi Arabia is extremely hot and windy. In springtime the temperature will remain above 100° for days, and in summer it often reaches 115°. The wind can be equally persistent, frequently filling the air with sand far over the Persian Gulf. Climate wrote the specifications for the spacious, modern cottages now being built at Dammam for married employees. These homes are cool and low-slung, fitting so snugly on the desert, in fact, that they may be called streamlined. In construction they are a combination of frame and native masonry. The native parts are limestone, used as wall material or filler, and *gutch* (gypsum), used in plastering. Everything else in a cottage must be shipped from the United States, including lumber, and everything is at present unloaded at Bahrein and transported by native *dhows* to Saudi Arabia. The company is building a terminal at Ras Tanura, which, when finished, can be used as the port of entry for all shipments.

All the new houses are air-conditioned. The method used is the standard central community unit. In each house the air is circulated past coils through which cold water is circulated.

There are about 180 men from the United States in Saudi Arabia, a few of whom are accompanied by their families. In addition, the company employs 2500 local workers. To make complete provision for all the community activities of the group a club building, hospital, large commissary, and large central dining room for men are now being designed in San Francisco and will shortly begin to take their places in the life of Dammam.

The company has of course been obliged to build its own power plant. It provides light for the main camp at Dammam and whatever additional power is needed there. At Ras Tanura, the new terminal site, all requirements can at present be supplied by a small, portable power plant.

Oil is a prize to be sought more intently, more scientifically, as the wheels of the world turn faster. This idea stimulates the thoughts of the entire colony of pioneers at Dammam, and the drilling lessons learned each day on this big dome are discussed each evening around dozens of dinner tables. So far, the major conclusion must be that commercial production on the Arabian mainland begins at the 4700-ft. level, in what is known as the Arab Zone. The company began its first test drilling in 1935, with ten wells. From the meager output of these it was concluded that deeper drilling would produce more oil. Within two years that conclusion was amply borne out and now, as the wells are brought in, the flow of each is restricted to 2000 bbl. a day to conform to good oil field practice.

In one important respect, the wells on Dammam Dome are fortunately located. They are less than 50 miles from the Bahrein refinery, which began operating in 1936, and 5000 bbl. of oil a day is now being transported by a 6-in. pipe line to Al Khobar and thence to Bahrein by barge.

It is 43 miles from Dammam to Ras Tanura, and construction of a 10-in. pipe line to connect the wells with the new company port is being hurried. Owing to the absence of deep-water docking facilities at Ras Tanura, the company is also building a 12-in. submarine line for use in loading the tankers, which anchor some distance from shore. All undersea pipe line is coated with Somastic pipe coating to prevent corrosion, and about 15 miles of the 10-in. line that crosses the desert to the terminal will also be coated.

As may be surmised, there is now a good deal of passenger and freight traffic between Al Khobar and Bahrein, requiring sailings every day. To provide convenient and more comfortable gulf transportation for its men and their families, the company has just built two 53-ft., Diesel-powered boats to carry passengers, mail, and express between Al Khobar and the island. One is already at Saudi Arabia and the other is on its way there. Two slightly larger boats, one of which is now in service, will be used as tugs.

At unloading time, the piers of Saudi Arabia are scenes of great activity.

Camels still do most of the heavy hauling, but a large, low-pressure tire has been developed to permit company autos to go anywhere in the desert

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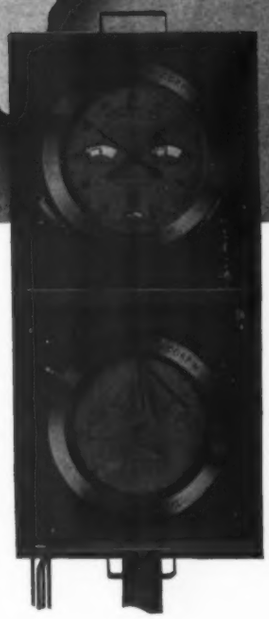

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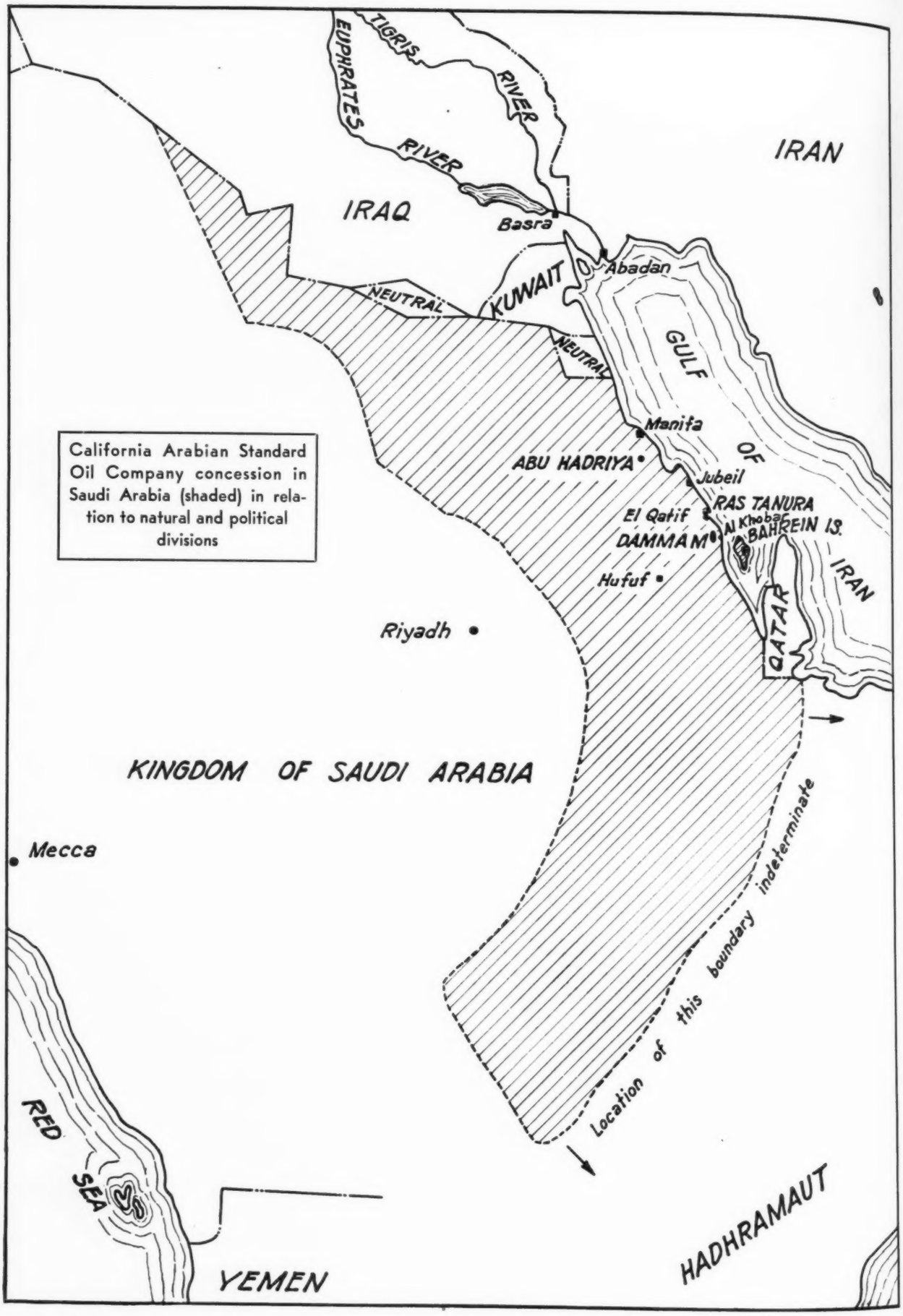


California Arabian Standard Oil Company concession in Saudi Arabia (shaded) in relation to natural and political divisions

Large tanks have been constructed for oil storage at Dammam and Ras Tanura

Traveling cranes, some on caterpillars, and rigid stationary cranes do the type of work formerly done at a much more leisurely pace by camels and donkeys. The animation is heightened everywhere by the movement of the Arabs, dressed in their flowing *aba,* or native outer garment.

The community of interest among the men in Saudi Arabia can be carried from Dammam across hundreds of miles of desert, to the farthest exploring party, by means of voice transmission. Portable radio sets made in the United States were provided for this purpose, and enable geological and geophysical field parties to communicate at all times with the main camp and with one another. These compact little sets are also carried by the two new passenger launches, the *Caljubail* and the *Calquatif,* for greater safety on gulf crossings during squally weather.

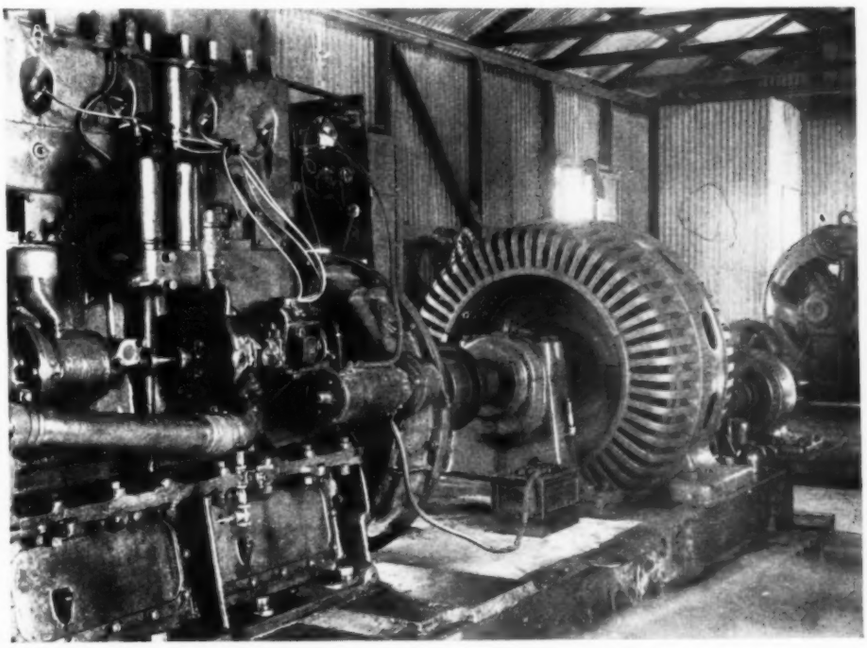
The modern efficiency of this form of communication is rivaled by the geophysical men in their use of the seismograph. Within comparatively recent years, this sensitive instrument has been given a new job. By the aid of light blasting in miniature "wells," and by recording the reflected sound waves, it is made to locate the geological strata of the earth.

Nor is the work of the company's field men confined to blasting and charting the surface of Saudi Arabia. The Arabs, who had been content for centuries to draw water from the rarely found desert wells by camel and donkey power, are now observing that applied science can make the water rise by itself. There are numerous artesian wells, which the company has been glad to "bring in" for the people of King Ibn Sa'ud.

Finally, no record of American community-building abroad would be complete if it overlooked the facilities for recreation. A tennis court, lighted for night play, has been built at Dammam and two or three holes of a golf course have been completed. There is a club house, containing a large room for card-playing and reading. On the coast there is swimming and fishing. The Arabians use fish-traps in the gulf to catch prawns, which grow extremely large, and there is a variety of other edible fish. In the desert, the gazelle hunting is good and the falconry even more fascinating, for it is a sport of kings and thousands of years of skill and tradition lie behind it.

Falcons are trained to their hunting art so gradually, so carefully, that a virtual profession has grown around the sport in Saudi Arabia. Stables are kept for the birds and they have their attendants, or servants, very much as blooded horses have in the United States. Forbidding of expression though these birds are, the days and years of their training and care make them fiercely devoted to their owners. The patience with which falconry has been developed and elaborated in Arabia, since ancient times, gives a dependable insight into the changelessness of the Arabian people, not only in their sports but in their national way of life.

This chosen way and the Moslem creed are one and inseparable. Students of Arabian history and present-day culture have said of King Ibn Sa'ud that his strength with the people of his kingdom lies in an unswerving devotion to the teachings of Mohammed. His prudent, democratic rule has given Saudi Arabia the greatest unity it has had in centuries—a singleness of aim in which all tribes can participate. In the present oil development, Saudi Arabia gives promise of having found a new economic anchor, which can only add to its future security as a nation.



Power house that supplies all electricity for Dammam and Ras Tanura

That the FACTS DRILLING

Judge James C. Wilson, Judge of the United States District Court for the Northern District of Texas, at Ft. Worth, filed his opinion in the case of the Hughes Tool Company vs. United Machine Company, et al, holding the patents in suit in that case owned by Hughes Tool Company were valid and infringed by the defendants, the United Machine Company. The following excerpts are taken from that opinion:

"Defendants are exclusively in the business of repairing, as they call it, plaintiff's bits. They contend that even though the claims relied upon are held to cover the accused devices, their acts here complained of do not constitute infringement of the patents in suit, under the rule of permissible repair.

"It is plain both in principle and in view of the pertinent decided cases that this rebuilding or any building-up of the worn teeth of the cutters is not a mere 'sharpening' of the cutters as defendants contend, but is a reconstruction that infringes the claim relied on of the Scott & Wellensiek patent No. 1,647,753 and the Fletcher patent, No. 1,856,627 respectively. When the cones are mounted to 'interfit,' it is an infringement of the Scott patent, No. 1,480,014, as well. The use by the defendants of metallic material of the used bits to make these devices is no less an infringement than would be the use of new metal therefor.

"The same observations are applicable to the bearing patents in suit in respect to the building up of the used device with new metal in the worn ball raceways or roller raceways or similar parts.

"The defendants contend that since they in instances worked on Hughes Tool Company bits at the request of drillers possessing them, they should not be held for infringement. This is unsound. I have pointed out that what defendants did was to reconstruct and without right. The drillers had no such right and would not have possessed it had title to the bits been in them. Of course a pat-

may be Known to the INDUSTRY

ented device may be repaired without infringement, if what is done is repairing in the sense of that word as applied to patented articles. The truth is what the defendants do is not repairing in any sense. It is rebuilding.

"As further bearing upon this issue, the plaintiff adduced testimony to show that defendants have no right to rework the Hughes bits because they are the property of the plaintiff. That evidence shows that title to the bits remains in plaintiff at all times.

"The defendants could, therefore, acquire no right to either repair or reconstruct from the driller as the driller had no such right to exercise or to transfer. Indeed, the driller is obligated to turn the plaintiff's bits back to the plaintiff and to no other.

"It follows that the defendants' conduct is without right on this ground alone, though as has been pointed out, infringement by the defendants has been clearly shown by the consideration hereinbefore set forth."

FOR 30 years HUGHES TOOL COMPANY has accepted as its obligation—the making available to the Drilling Industry of a safe, fast, economical Rotary Rock Bit.

Drilling requirements have been anticipated; lower footage costs assured—year by year; a new and better Hughes Rock Bit always "in the making."

This continuous program of laboratory and field experiments, involving enormous expenditures, can be continued only so long as the results of research and invention are available for further experiment and development.

HUGHES TOOL COMPANY
HOUSTON, TEXAS

Wild Well Quickly Subdued

By BRAD SMITH

MODERN methods of fighting wild wells were demonstrated when the E. A. Schmitt No. 1 Flores, on the north edge of the Samfordyce field, Texas, blew out and ran wild from a depth of 3000 ft. while drilling tools were out of the hole and the crew was preparing to make a production test. Casing had been cemented and the bottom-hole pressure was about 2000 pounds.

The well was audible for more than two miles after it blew out. It was producing virtually no water, a large volume of gas, and a dangerous amount of sand and small gravel. (Fig. 1). It had been blowing for several days when H. L. Patton, the wild-well fighter from Houston, Texas, was called.

By the time the crew arrived, sand and gravel had partly wrecked the "crow's nest" and the entire derrick and rig were threatened with destruction. (Fig. 2).

A truck was backed to the derrick floor and a 10-ton manifold dropped into the open casing, all valves being open. (Fig. 3).

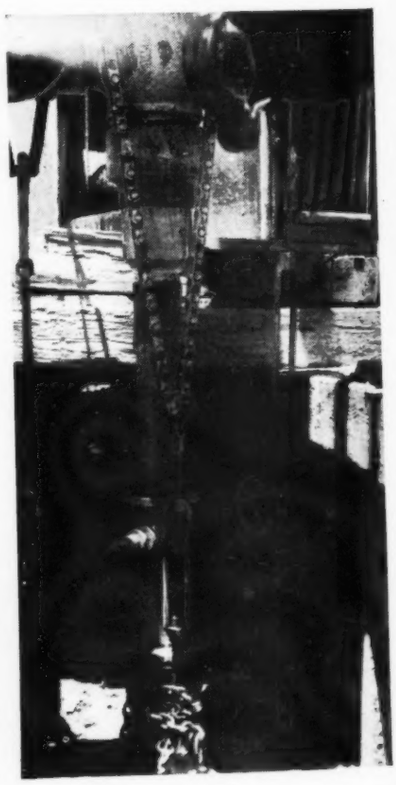
The tapered manifold was forced into the casinghead and heavy cables and turn-buckles were used to effect a gas-tight seal. (Fig. 4). Just above the derrick floor was the main control valve on the manifold. When the manifold was safely tied into the casinghead, this valve was closed and the well was once more under control. Mud pumped into the well through connections on the manifold completed the job.

Fig. 1

Fig. 2

Fig. 3

Fig. 4



Running Tour
WITH MEN IN THE INDUSTRY

F. E. REHM has been promoted by the Shell Oil Company from production manager to manager of the labor relations department and his headquarters have been transferred from Los Angeles to San Francisco, California.

R. H. McLEMORE, production engineer at Beeville, Texas, for the Sun Oil Company, recently was transferred to the production department in the Dallas office.

EDWIN THORNTON, chief chemist, National Oil Refineries, Ltd., has been elected chairman of the South Wales branch of the Institute of Chemistry.

W. A. TIPTON, manager of packing sales, Mechanical Goods Division, United States Rubber Products, Inc., New York City, is making a tour of Mid-Continent and Gulf Coast oil fields and visiting the company's branches in the area.

PATRICK ASHLEY COOPER has been appointed a director and chairman of the Trinidad Leaseholds, Ltd., London, England, and **R. BEAUMONT,** managing director, has been made deputy-chairman.

LLOYD L. JORDAN has been employed as senior gas engineer by the Arkansas Board of Conservation, it is announced by **O. C. BAILEY,** chairman of the Board. Jordan is a graduate of Ouachita College, Arkadelphia, Arkansas, and after graduation joined the Sinclair-Prairie Oil Company. In 1934 he became gas engineer with the Lion Oil Refining Company and remained with that company until he accepted a post with the Arkansas Board of Conservation. This increases the Board's engineering personnel to six men.

LLOYD L. JORDAN

PROF. J. S. S. BRAME, London, England, has resigned as chairman of the Chemical Standardization Committee of the Council of the Institute of Petroleum.

W. D. RICHARDSON, Fort Worth, Texas, vice-president and a director of the Cosden Petroleum Corporation, has resigned and will operate independently in the future, it is announced.

FRED S. WRIGHT, JR., graduate of the University of California, has been added to the engineering staff of Magnolia Petroleum Company, and assigned to the Chase, Kansas, district. His headquarters are at Ellinwood.

MERLE KAHL, tool pusher for the International Petroleum Company in Peru, will return home shortly after a visit to Los Angeles, California.

W. R. ABBOTT, president of the Aetna Refining Company, Louisville, Kentucky, has been elected president of the Birk City Oil Company, successor of the Hoosier Drilling Company.

DAN S. KEENAN, vice-president of the Carnegie Natural Gas Company and the Apollo Gas Company, has been made president of both firms to succeed the late **S. W. MEALS.**

BOUWE DYKSTRA, chief exploitation engineer of the Shell Petroleum Corporation, Tulsa, Oklahoma, has been transferred to the Shell Development Company staff in California.

H. W. MANLEY, on March 1, will succeed **A. J. SCHLOSSER** as superintendent of the gas and natural gasoline department of the Barnsdall Oil Company, Tulsa, Oklahoma, who retires on that date after 34 years service with the company. Manley has been division engineer and assistant to Schlosser.

C. M. HALL, superintendent for George F. Getty, Inc., in the Santa Fe Springs area, has been transferred to Bakersfield, California.

FRED J. SPURLOCK has been appointed sales manager of the Mid-Continent Supply Company. Spurlock is well known in the petroleum industry, having had a wide and varied experience in the oil-well supply business. He has been connected with the Mid-Continent Supply Company for many years in various capacities, his most recent assignment being in charge of the company's pumping equipment division. Spurlock has moved to Fort Worth, Texas, and he will have his headquarters in the company's general offices in the Mid-Continent Building.

FRED J. SPURLOCK

R. E. GREENWOOD has been appointed district sales manager of the Chicago territory of the American Chain Divison, American Chain and Cable Company, Inc., having his headquarters at 400 West Madison Street, Chicago, Illinois. He succeeds **G. B. KUTZ** who has been transferred to York, Pennsylvania, as assistant to the general manager of sales. **R. C. BRENIZER** has been appointed Philadelphia district sales manager of the American Chain Division, his headquarters being at Second and Diamond Streets, Philadelphia, Pennsylvania, succeeding Greenwood.

WILLIAM H. FOGARTY, who has spent 27 of his 30 years with Johns-Manville in the company's Chicago office, has been transferred from the Chicago district managership of the power products department to assistant to the vice-president of the J-M Sales Corporation. In his new position, Fogarty will continue to make his headquarters in Chicago. He will be succeeded as district manager by **CORYDON H. HALL,** who for the last three years has been assistant sales manager in J-M's New York power products district.

CHARLES F. STEVENSON, general manager of operations in Pennsylvania and New York for the South Penn Oil Company, has been made vice-president of the company. **FRANK SCHELL,** superintendent of drilling operations in the Bradford area, is the new general manager, and **J. L. O'NEIL,** superintendent in the Oil City district, succeeds Schell. O'Neil's vacated post will be occupied by **CLARENCE GRAHAM,** assistant superintendent of tools in the Bradford field.

ARTHUR J. WILLIAMSON has been added to the technical staff of Summerill Tubing Company, Bridgeport, Pennsylvania, as metallurgical engineer in charge of research and development. During the last four years he has been research metallurgist for John A. Roebling's Sons Company, Trenton, New Jersey.

V. E. COTTINGHAM is head of the North Basin Engineering Committee organized by operators in Gaines, Yoakum, Cochran, and Slaughter counties, Texas.

J. A. BURNETT, president, Flathead Refining Company, has moved his headquarters from Kalispell, Montana, to Spokane, Washington.

WILLIAM P. BRADBURY, 53, vice-president and general sales manager of the Consolidated Ashcroft Hancock Division of Manning, Maxwell and Moore, Inc., Bridgeport, Connecticut, died recently of pneumonia after a six-day illness. Bradbury joined Manning, Maxwell and Moore, in 1902 as an office boy. In 1923 he was made general sales manager and in 1930 vice-president in charge of sales, the position he held until his death.

R. L. AKIN, superintendent for the British American Oil Producing Company, is now making his headquarters in Dallas, Texas. He formerly was in Tulsa, Oklahoma.

P. D. GROMMAN, JR., petroleum engineer, The Texas Company, is now located in Fort Worth district office of the company. He formerly was at Wink, Texas.

A. E. CHESTER, engineer, Socony-Vacuum Oil Company, is now making his headquarters at Salem, Illinois. He formerly was at Mount Pleasant, Michigan.

L. H. RUSSELL, drilling superintendent for the Turkish Government, is visiting the oil fields of Texas.

W. A. HUBER has been appointed manager of sales of the Gilmore Wire Rope Division of the Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania. Huber has been with J. & L. since 1936 and prior to that was in public accounting and sales work for a number of years.

W. A. HUBER

RALPH J. SCHILTHUIS, engineer in the management and statistical research department of the Humble Oil and Refining Company, Houston, Texas, has been awarded an Alfred Noble prize for his paper, "Connate Water in Oil and Gas Sands," presented before the American Institute of Mining and Metallurgical Engineers. The prize carries with it a cash award of $500, a suitable certificate, and traveling expenses to attend the annual meeting of the American Institute of Mining and Metallurgical Engineers in New York, February 15.

The award is given for a technical paper prepared by an author not more than 30 years of age.

LLOYD G. ENSIGN, export representative for Hercules Tool Company, recently spent the day in Tulsa, Oklahoma, in conference with executives of the company. In addition to analyzing export sales possibilities of several new Hercules oil well specialties, Ensign visited the company's plant before returning to his office in New York City.

KUHN CALVERT, field superintendent for the Burmah Oil Company, is now in Los Angeles, California, on a visit. During the absence of **T. J. F. ARMSTRONG,** who recently returned to Burma from a trip to the United States, Calvert took Armstrong's place in the conduct of operations in Burma.

O. L. CORDELL has been named president of the Barnsdall Refining Company to succeed **E. B. REESER,** who resigned but continues as president of the Barnsdall Oil Corporation, producing and pipe line division of the Barnsdall interests, as well as a director of the refining and marketing division.

MAURICE WEBB, engineer of the Warren Petroleum Company, has been transferred from Harjo, Oklahoma, to Monument, New Mexico.

BARNEY BARNARD of the Goodall Rubber Company of Texas, Houston, Texas, has returned from a trip to the Goodall factory at Trenton, New Jersey.

W. B. EMERY, geologist for the Ohio Oil Company, having his headquarters at Casper, Wyoming, has been transferred to Findlay, Ohio.

F. G. BOK, engineer, has been transferred by the Shell Oil Company from Los Angeles to Bakersfield, California.

O. E. DEMPSEY, of Kelley-Dempsey and Company, Tulsa, Oklahoma, pipe-line contractors, left for Venezuela early in February to be gone two weeks.

J. A. SMITS is now in California from The Hague studying new equipment and methods used in the state. He will be in the United States for sometime and will visit other parts of the country before he returns.

PIET SCHOUTE, exploration engineer for B.P.M. in the Netherland East Indies, is now in Los Angeles, California. During his stay in the United States he is studying equipment and methods of operation.

J. ANGYOL, engineer for the Europen Gas and Electric Company of Hungary is expected to reach Los Angeles, California, in March. **F. DINDA,** engineer for the same company, is now in Texas.

BILL GROGAN, tool pusher for Standard Oil Company of Venezuela, has just returned to Eastern Venezuela after a visit to Los Angeles, California.

J. W. KILLINGSWORTH will leave Los Angeles, California sometime in February to serve as driller for the Iraq Petroleum Company in Iraq.

C. H. FENWELL, driller for Anglo-Ecuadorian Oilfields, Ltd., has been visiting in Los Angeles.

M. P. LEWIS, former Eastern district manager, wire sales, for United States Rubber Company, has been appointed assistant manager, Wire Sales Department, having headquarters at the company's main office, 1790 Broadway, New York City. **H. H. WEBER,** assistant manager, Wire Sales Department, since 1934, has been appointed commercial engineer of that department. Previously, he was in the engineering division of the Rome Wire Company and the General Cable Corporation. Succeeding Lewis as manager of wire sales for the Eastern district will be **H. J. MacDONALD.** Appointed to the post formerly held by Macdonald is **C. W. SHORT.**

J. L. MAUTHE, superintendent of the Youngstown Sheet and Tube Company's plants at Campbell and Brier Hill, Pennsylvania, and at Hubbard, Ohio, has been appointed to the board of trustees of Pennsylvania State College. He will occupy the place made vacant by the death of **HUGH M. CLARKE** of Lancaster.

ERNEST K. PARKS, head of production engineering in the southern district for the Standard Oil Company of California, has resigned after 14 years with that company. He will continue to be identified with the oil industry but has not made known definitely his plans.

JAMES M. McPHEE has been appointed California division manager for the Lane-Wells Company.

H. L. J. HUNTER, drilling superintendent, Anglo-Iranian Oil Company, London, England, has been a recent visitor on the Gulf Coast, studying drilling and well-completion technique.

A. C. H. COOKE, Houston, Texas, has been transferred to Oklahoma City, Oklahoma, as division engineer of the Lane-Wells Company. **F. O. BOHN** is the new division engineer of the Gulf Coast Division.

LIONEL W. WIEDEY, geologist for the International Petroleum Company, Negritos, Peru, was a visitor on the Pacific Coast recently.

L. M. JOHNSTON, engineer, Cheyenne, Wyoming, has been hired to supervise construction of the Consumers Cooperative Association's 3000-bbl. refinery in northwest Kansas.

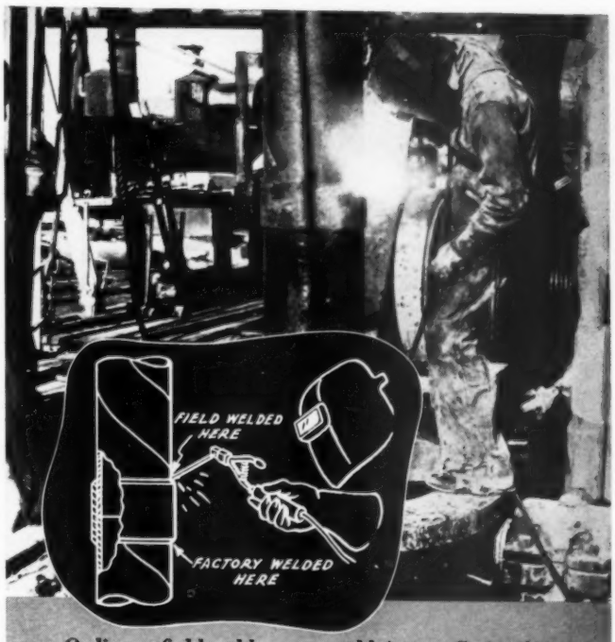
R. R. COWAN, Midland, Texas, has been appointed resident manager at Hobbs, New Mexico, by the Arrow Supply Company, Inc., Fort Worth, Texas. Cowan has been West Texas and New Mexico manager for Emsco Derrick and Equipment Company for the last four years. Prior to joining Emsco he was connected with the National Supply Company for 12 years as store manager at Oklahoma City, Stroud, and various other points in Oklahoma.

W. A. BROWN, formerly of the Mene Grande Oil Company, and who has been on leave in the United States, has accepted a position as drilling superintendent with the Caracas Petroleum Corporation and will leave for Caracas, Venezuela, February 24.

ALBERT W. BAXTER, chemist on the Abadan staff of the Anglo-Iranian Oil Company, has been elected an associate of the Institute of Chemistry of Great Britain and Ireland.

YOU GET A TIGHTER JOINT

AT LESS EXPENSE



Ordinary field welders can weld Armco Casing because it's made of a special high quality weldable steel. Then too, the metal flows easier because the weld is laid flat against a 5/16-inch metal collar.

• Thrifty oil men everywhere are discovering that Armco Slip-Joint Casing is a real money-saver for conductor lines that are cemented in and never pulled.

One big reason is that Armco Casing eliminates the unnecessary expense of threaded ends. This saves you $29 a joint on 13⅜-inch, 48-pound pipe—a total saving of $580 in 600 feet, which more than offsets the cost of field welding. Besides, the field-welded slip joint gives you a tight, leak-proof connection with plenty of strength to withstand the conditions met in surface strings.

You'll also find Armco Casing easier to handle and set because it's free of excess weight. No special slips or elevators are required and each length lines up accurately in the slip-joint collar without need for special clamps. For immediate delivery of Armco Casing in standard sizes, just call the nearest store of our distributor, or address: The American Rolling Mill Co., Pipe Sales Division, Middletown, Ohio; 538 Mayo Bldg., Tulsa, Okla.; 3500 Maury St., Houston, Texas.

ARMCO
SURFACE CASING
Distributed By
NATIONAL TANK COMPANY
Tulsa, Oklahoma, and Branches

LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

The Winnah!

A flapper was permitted the use of her father's car only on the promise that she would not drive over forty miles an hour. Forty was reached with such ridiculous ease—and fifty just a wee bit of throttle beyond—the first thing the girl knew a motorcycle appeared in the "cop detector." She was in for a ticket, dad's wrath, and no more use of the car.

She obeyed her first impulse and tramped on the accelerator, hoping to lose the law in her dust. Sixty—seventy—eighty—and finally ninety! But the motorcycle stayed with her.

Suddenly she spied a filling station about a mile down the road. She put everything she had into reaching it. And when almost abreast of it, she slammed on the brakes, screeched to a stop, and made a wild dash for the rest room, leaving the motor running and the car door open.

Ten minutes later, while the irate cop stood by, notebook in hand, a bawling out at the end of his tongue, she emerged demurely from the rest room, powdering her nose. Before the copper could get in a word, she flashed a golden smile on him, and with a great sigh of relief said, "Boy! that was a close one. I just made it!"—*Typing Tips.*

* * *

After a hard day's trip on a coast to coast bus, during which there were numerous stops, an old lady complained to the driver.

"Say, young man, seems like we stop at every other telephone pole."

"Well, mam," the driver replied, "This is a Greyhound Bus."

* * *

Lecturer: Of course, you all know what the inside of a corpuscle is like.

Chairman of meeting (interrupting): Most of us do, but you better explain for the benefit of them as has never been inside one.

* * *

A checkered career often ends in a striped suit.

* * *

Then there was the Scotchman who was born in this country to save transportation.

* * *

Seeing two women meet and kiss somehow always reminds us of prizefighters shaking hands before their bout.

The Petroleum Engineer,
P. O. Box 1589,
Dallas, Texas.
Gentlemen:

Barney jests about pealing a couple of the town bells, but it is not a subject for levity. I know, for when I tried it the belle tolled.

For obvious reasons,
Anonymous Subscriber.

* * *

A certain old maid had a pet mama cat that she kept confined at home. This winter she took a southern cruise and wrote the following letter home: "I'm having more darn fun . . . met a swell guy on the boat and have been having dinner and cocktails with him every evening. It's the swellest time I've ever had."

P. S.—"Let the cat out tonight."

* * *

Two Georgia darkeys were discussing the financial condition of the country. They didn't agree.

"You's all wrong," one vociferated. "Dey ain't no money sho'tage. Ah asked mah bankah is he out o' money and he tuk me in de vault an' showed me piles an' piles o' money. And Ah says could he let me have a little. And he says he sho' could. Has Ah any collat'rual? Ah hasn't. Now, dat's what's the mattuh wid this country. Dey's plenty o' money, but we's just runnin' sho't on collat'rual."

* * *

A tiny girl asked her Scotch parents: "Mother, what are prayers?"

"Messages to heaven, my dear," replied the mother.

"Then that is why father always says his prayers at night—to get the low rate."

* * *

Discussing the type of milk that should be supplied to school children, the chairman of the town's health committee said:

"What this town needs is a supply of clean, fresh milk, and we should take the bull by the horns and demand it."

* * *

Fast Thinking

Mrs. McTavish (looking out window): Sandy, here comes company for supper.

McTavish: Quick, everybody run out on the porch with a toothpick!

Political Independence

Census Taker: How many in your family, madam?

She, snappily: Five—me, the old man, kid, cow, and cat.

"And the politics of your family?"

"Mixed—I'm a Republican, the old man's a Democrat, the kid's wet, the cow's dry, and the cat's a Mormon."

* * *

A man's looks are spoiled when he sneers, especially when he sneers at a bigger man.—*Our Sun.*

* * *

It seems that Mary was a small wheat seed and was planted in Western Kansas. Mary thrived on the sun and moisture and grew into a beautiful stalk of wheat. She would dance all day in the wind and sleep very soundly at night. As Mary grew bigger and finer, she started to dance all day with Oscar, an adjoining wheat stalk.

Mary and Oscar, after dancing all day, became very well acquainted and one night Mary put her head on Oscar's shoulder and went to sleep. The next morning when she awakened, it was pitch dark. In terror she looked around and found that she was in a loaf of bread and then cried, "My God, I've been Reaped!"

* * *

State highway patrol: Have you a driver's license?

Motorist: Sure I have. Want to see it?

Obliging patrol: Naw, drive on. It's when they don't have it that I insist on seeing it.

* * *

Pa: I think I'll have to go downstairs and send Nancy's young man home.

Ma: Now, Elmer, don't be hasty. Remember how we used to court.

Pa: For gosh sakes; I hadn't thought of that. Out he goes.

* * *

High Finance

Judge: Did you break into the bank vault and steal this money?

Prisoner at the bar: No, your honor, I merely borrowed it to deposit it in an affiliate which gave as its collateral a subsidiary which hypothecated its equity.

Judge: Case dismissed.

MACHINERY MANUFACTURER

DEALER

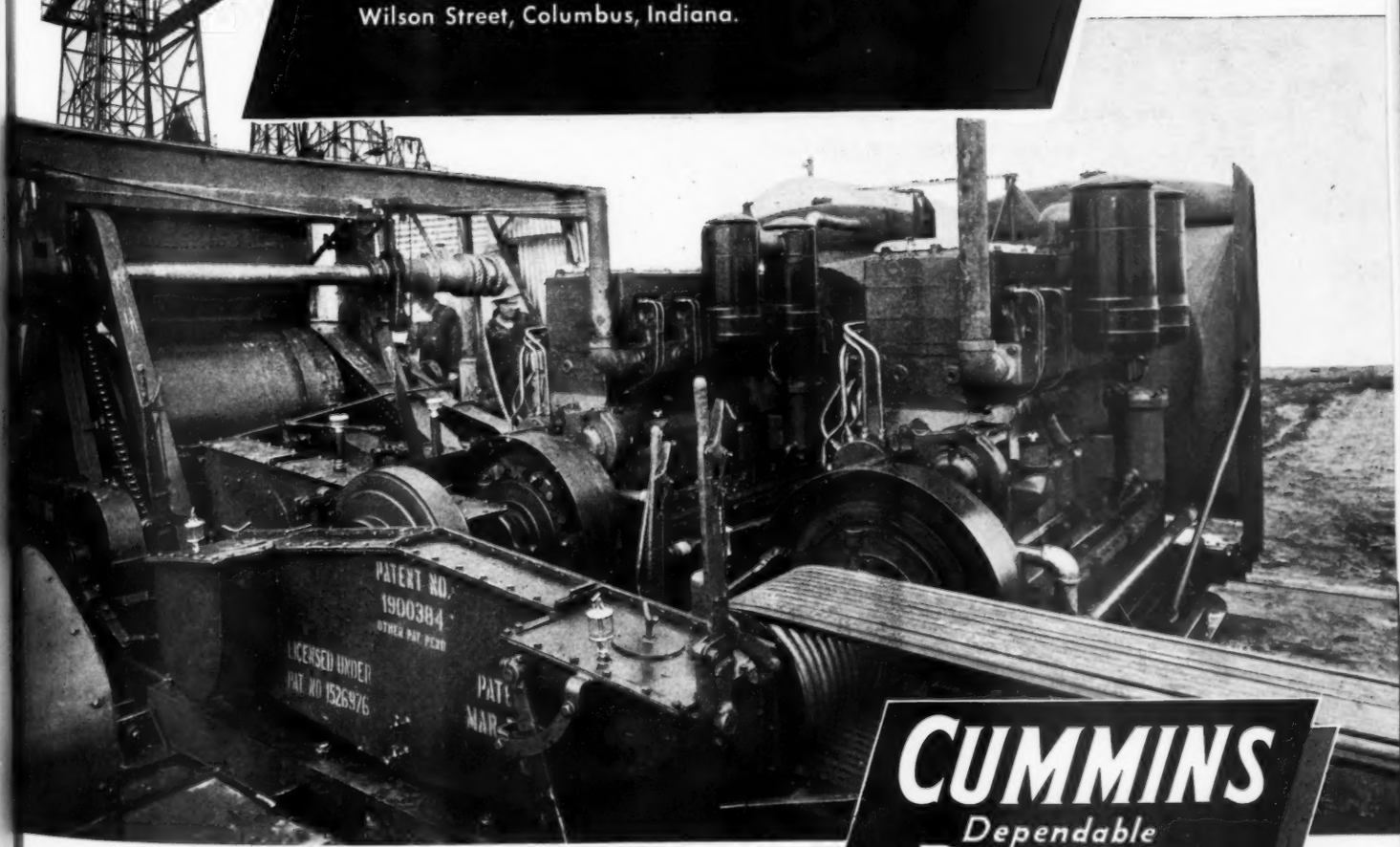
ENGINE BUILDER

No Three Cornered Service Problem when you buy CUMMINS dependable DIESEL

Whether you buy new equipment powered with Cummins Diesels or re-power your old, you are assured the backing of a national service organization.

The responsibility for servicing your Cummins Diesel is in the hands of a crew of factory-trained service men and your local Cummins representative — no matter from whom you may have bought your equipment.

This means no divided responsibility — no question whom to call — should accident or emergency demand instant attention. Cummins Engine Company, 1516 Wilson Street, Columbus, Indiana.



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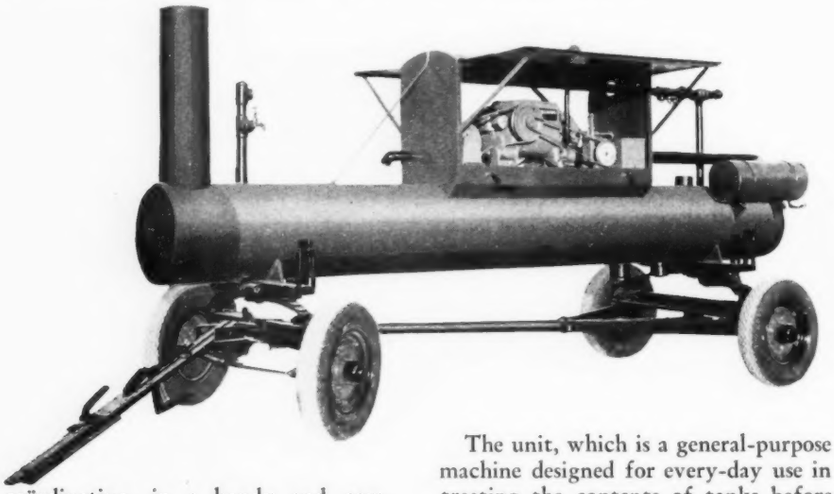
Dependable
DIESEL
PIONEER IN MODERN DIESEL DEVELOPMENT

MID-CONTINENT SUPPLY COMPANY
Exclusive Distributors Mid-Continent Territory • **FORT WORTH, TEXAS**
other oil fields—ask any representative of such well-known oil-field equipment manufacturers as:
American Well & Prospecting Co. • Emsco • Ideco • Wilson • All Steel • Portable • Bridgeport, or Franks

MACHINERY and EQUIPMENT

Portable Oil Treater

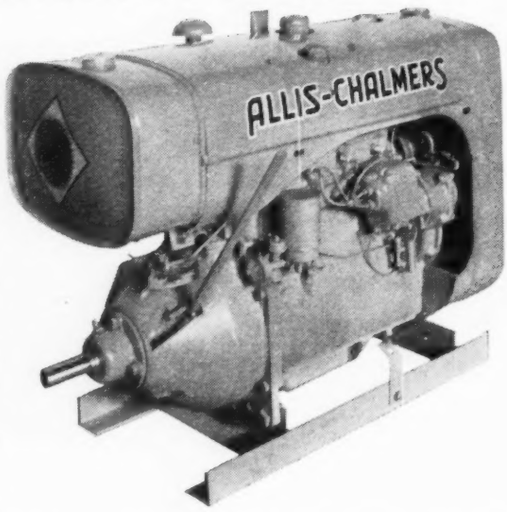
A NEW portable oil treater manufactured and distributed by the Bridgeport Machine Company is designed to replace the conventional boiler-heater for treating oil containing water emulsions, by combining and coördinating, in a handy and compact unit, the functions of heat, circulation, and chemical treatment, augmented by vibration.



The unit, which is a general-purpose machine designed for every-day use in treating the contents of tanks before the oil is run to the pipe line, as well as for recovering accumulated waste oil from tank bottoms and disposal pits, is said to be successfully treating petroleum emulsions of various types in many fields. A treatise on "Petroleum Emulsion Treating" and complete description of the treater may be had by writing the Bridgeport Machine Company, Wichita, Kansas, for Bulletin No. 200.

Allis-Chalmers Model B Power Engine

ALLIS-CHALMERS Manufacturing Company, Milwaukee, Wisconsin, announces the Model B power engine, adaptable to the smaller type oil field power applications. The Model B has a 74 ft-lb. torque at 1100 r.p.m. It is a 4-cylinder engine having a 3¼-in. bore and 3½-in. stroke. The piston displacement is 116 cu. in. This engine has the same removable sleeves that have proved so successful on the larger sizes of Allis-Chalmers engines, the makers state, which is a feature for an engine of its size. Re-boring is eliminated. Lubrication is under pressure to all working parts. Water is circulated by a high-velocity pump. Equipment includes a carburetor, an oil-wash air cleaner, a high-tension magneto, and a dry disc clutch. The engine is complete with radiator, fan, hood, and side plates, and will burn gasoline or natural gas.



Fred E. Cooper, Tulsa, Oklahoma, is oil field distributor for the equipment, having branches at Longview, Texas, and Los Angeles, California.

New Recorder for Temperature and Pressure

C. J. TAGLIABUE Manufacturing Company, Brooklyn, New York, announces a new "9" recorder for temperature and pressure, occupying half the space, but including every feature of the larger 10- and 12-in. recorders.

With the announcement of this new "9," Tag completes a line of recording instruments with 9-, 10-, and 12-in. charts. By compact arrangement in a small case, beautifully finished in black enamel and chromium, every feature found in the standard recorders is offered in these new instruments, it is asserted. These features include:

Interchangeable tube system that can be replaced readily and need be checked at one temperature only.

Pen arm bracket supported by bearing at both ends; no backlash; no lost motion.

Positive micrometer pen adjustment.

Safety link for range protection.

Handy door-latch that catches when door is swung closed; fastens when the handle is pushed downward.

Convenient chart holders, a turn of the knurled knob releases the gripping fingers and the chart slips over, nothing to remove or lose.

Nine in. chart having $3\frac{5}{16}$-in. pen travel assures open graduations for easy reading.

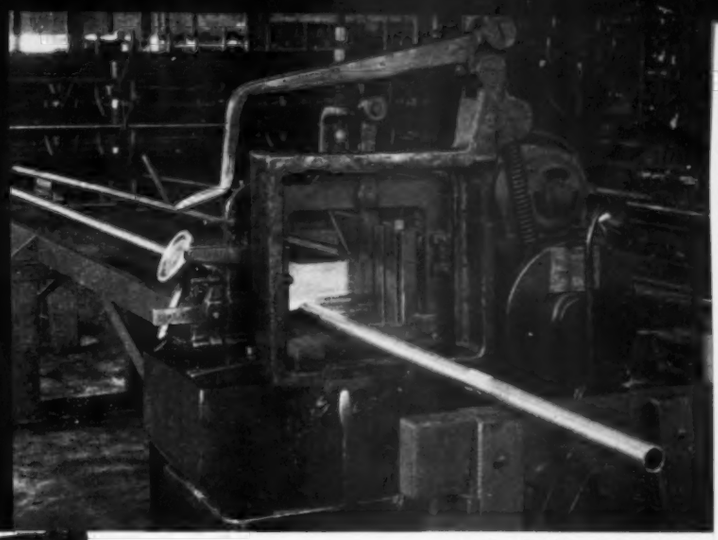
Visible-record stainless steel pen arm.

Removable capillary fountain pen, precision-built on the design of the draftsman's pen.

These are the operating conveniences and mechanical refinements found in all "9" recording instruments.

LIFE

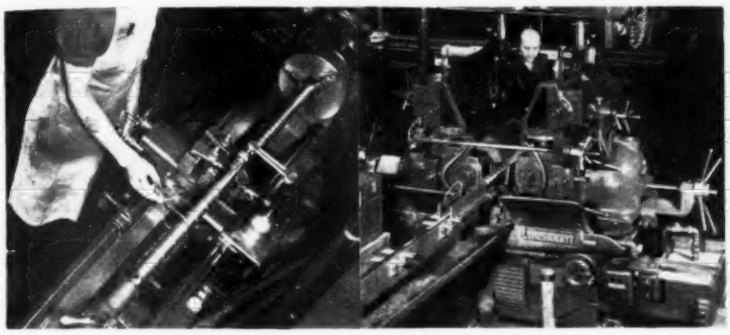
AT THE BOTTOM OF YOUR WELL



1. Cutting Plunger tubing to length.

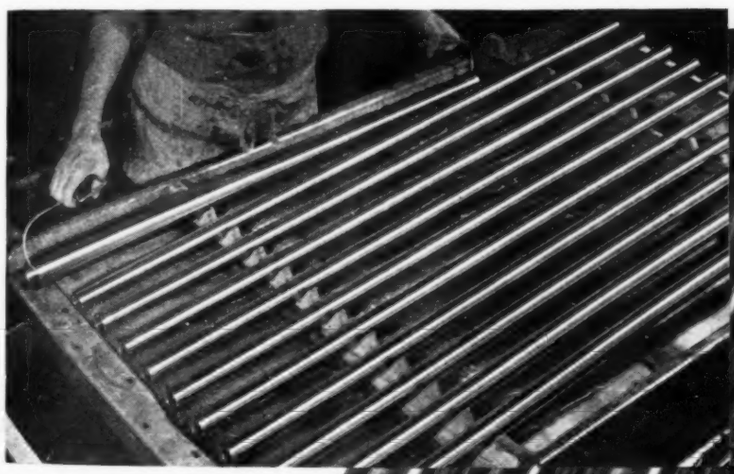
2. Heat treating Super-Service Plungers.

3. Testing Super-Service Plungers for hardness.

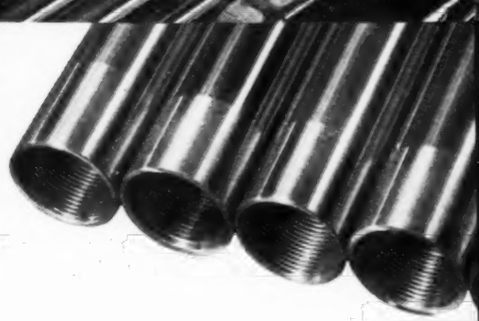


4. Turning grooves in Plungers.

5. Polishing Plungers to mirror finish.



6. Resting on fibre-covered racks, Axelson plungers are gaged and stamped to show exact diameter. After exact gaging, no hand touches the surface. They are transferred to the de-greasing and rust-preventing departments with bronze hooks inserted in the ends, to prevent the slightest scratch or blemish on the polished surface.



It's the plunger in your pump that lifts the oil. It's the quality of the steel in the plunger that makes it resist corrosion. It's the heat treatment that makes it hard and tough so that it will better stand up against the abrasion of sand and shale. It's the final finish to close tolerances that permits the proper fit with the liners, reducing friction and fluid slippage. It's the standardization to exact lengths, diameters and fits that enables you to replace plungers, if needed, without pulling your tubing.

It's all these fine points about Axelson plungers — together with countless other fine points about Axelson seats and balls, cages, collars, jackets, paraffine scrapers and final assembly, that give you positive assurance of long pump *life at the bottom of your well* and maximum production at minimum cost for power and maintenance as long as your oil lasts.

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

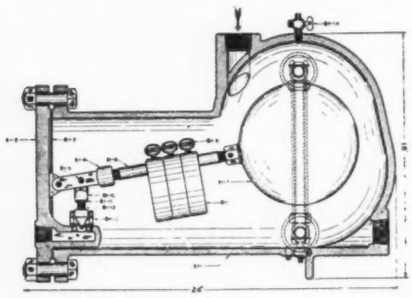
AXELSON

DEEP WELL PLUNGER PUMPS • SUCKER RODS

AXELSON MANUFACTURING COMPANY — P. O. Box 98, Vernon Station, Los Angeles • St. Louis • 50 Church Street, New York • Tulsa
Mid-Continent and Eastern Distributor: Frick-Reid Supply Corporation
Rocky Mountain Distributor: Great Northern Tool & Supply Company
Foreign Representatives: "COSMOS" Soc. in Nume Colectiv, Bucharest, Roumania • *Direct Factory Representative,* Bucharest, Roumania • Industrial Agencies, Ltd., San Fernando, Trinidad, British West Indies *Factory Representative,* Maracaibo, Venezuela • Armco International Corp., Buenos Aires, Argentina

Duo-Gravity Water Drainer

HANLON-WATERS, Inc., Tulsa, Oklahoma, announces the Hanlon-Waters Type 91 Duo-Gravity Drainer for use in continuously draining water condensate from vessels containing oils or distillates and for use on water knockout trays of gasoline plant stills, reflux accumulators, and for gasoline run tanks. The equipment is



available either in semi-steel for 150-lb. working pressure or electric cast steel for 500-lb. working pressure. The valve plugs and renewable seats are of 18-8 stainless steel, as are the float ball and fulcrum pins.

The following features are claimed for the equipment by the manufacturers: The complete absence of stuffing boxes reduces operating friction and maintenance to a minimum. Its friction free positive action insures tight closure when no water is being formed to prevent the loss of gasoline or oil. The float rod is counter-weighed so that the float will sink in the oil and float on the water and ride on the interface. The absence of outside levers, counterweights, and adjustments prevents tampering by unauthorized persons. All internal working parts are readily accessible by removing the head flange without disturbing the equalizing piping connections. The valve plug and seat are easily renewed, or can be replaced with larger or smaller sizes as desired. Overall construction is rugged and fool-proof. Complete capacity and calculation charts are available.

Hook-Ring for Woven Tapes

A FOLDING end hook of new pattern for woven tapes is offered by The Lufkin Rule Company, Saginaw, Michigan, and New York City. It is a feature of real value for it enables one man to take many measurements unassisted.

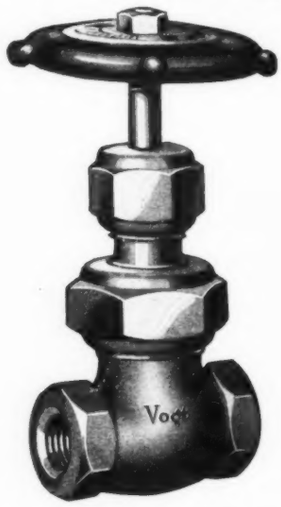
This is a small, yet sturdy, steel hook permanently affixed to tape ring, not detachable. It will hold tape at end of a board or pipe, corner of a building, and numerous other places, yet readily folds flat against the tape ring, out of the way, in no way hinder-

ing the use of the tape without the hook, and then also it will not catch objects or prevent the tape line being fully wound into the case. Friction holds the hook in position when open and closed. Zero falls at the inside of the open hook. The two prongs of this hook-ring are widely spaced, and each has an anchor spur, hence it takes a firm, square hold. The sure grip, when the tape is under tension, also prevents losing hold by side sway, yet the tape releases itself when tension is released.

Being permanently attached, this hook-ring is supplied only with tapes, not sold separately. It adds but 20 cents per tape to list price. It is offered on "Metallic," "Junior Metallic," and "Sterling" tapes bought either with case or as refills, i.e., lines only. Hook-ring is optional.

Vogt Union Bonnet-Type Meter Valves

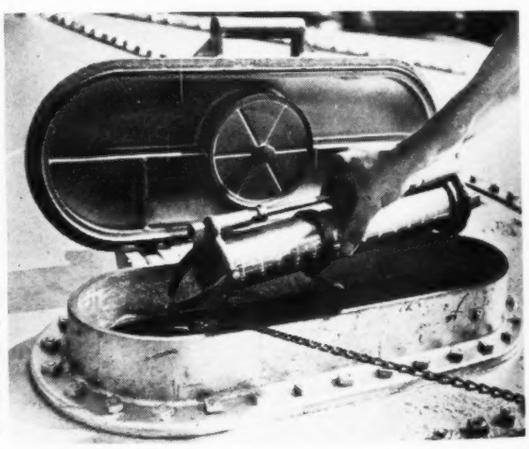
THE Henry Vogt Machine Company, Louisville, Kentucky, announces a line of drop-forged steel, union bonnet-type meter valves in ¼-,



⅜-, and ½-in. sizes. This valve has hexagon body ends, a ground joint between body and bonnet, and a stem that can be easily reground or replaced, and the valve may be repacked under pressure. Recommended for 900-lb. working pressure at 750 deg. fahr., or 1500-lb. non-shock cold working pressure, it may be had of all-carbon or all-stainless steel to suit.

B. S. & B. Thief Valve

BLACK, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma, announce their new "Long John" thief valve, so named because it is sufficiently large to permit complete execution of the gauger's work without removing the thief from the tank. It thus prevents erroneous gravity readings frequently caused by exposure of the thief to the hot sun, and eliminates the use of cumbersome, improvised catch-pans, and slopping of oil over tank decks and sides.



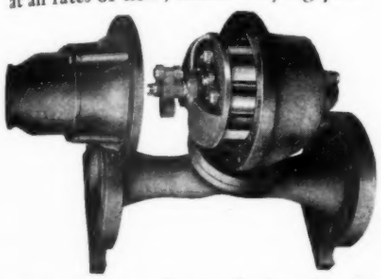
The inside dimensions of the thief valve opening are 8 in. by 22 in. A tray is suspended inside the opening that will accommodate an 18-in. oil thief on end wholly inside the tank and thief hole while indicated gravity is being taken.

The Neoprene pressure-sealing gasket in the thief valve lid is impervious to gas and oil. The lid is fitted with a 5½-in. diameter stainless steel vacuum valve and stainless steel valve stem held in place with bakelite nuts and washers. The materials used in construction of the complete thief valve insure a corrosion-free long life, even against sourest gas and oil. The valve maintains a two-ounce pressure and half-ounce vacuum.

Pipe-Line Meter Introduced By Pittsburgh Equitable

THE Rotocycle Meter, recently introduced by Pittsburgh Equitable Meter Company, is asserted by the manufacturer to be the first meter to be designed primarily for pipe-line service.

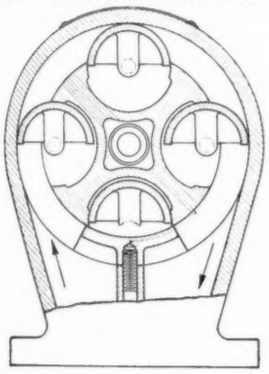
Described as a new development in positive displacement measurement, the Rotocycle is said to measure accurately at all rates of flow, under varying pres-



sure, specific gravity, and viscosity. It is stated that the meter is so designed that it will withstand the shocks and strains imposed by pipe-line pumping.

Pressure loss in pipe lines is an important factor that is receiving increasing attention. It is pointed out that use of the Rotocycle does not retard oil flow and there is no appreciable loss in pressure.

The Rotocycle is said by the makers to be the first positive displacement meter to have an operating mechanism consisting entirely of rotating parts. The meter consists of an elevated cylin-



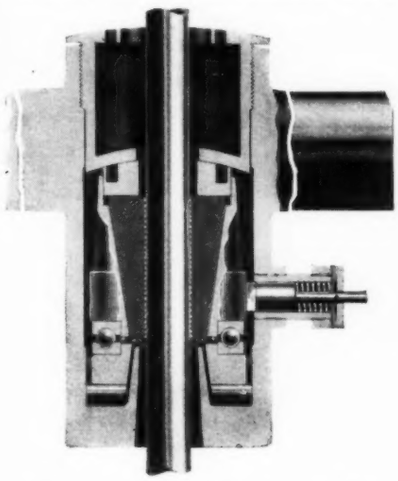
drical housing having inlet and outlet ports so designed that the oil flows in an unrestricted path.

The rotor or measuring element of the meter consists of a cylinder in which there are four half-moon shaped buckets equidistantly spaced on its outer surface and geared together on top of the rotor in a ratio of one to one. As the rotor turns, the position of these buckets with relation to the side walls of the measuring chamber varies, always, however, so that two buckets are in contact to form a closed compartment. The volume in this compartment is definite and these displacements are counted to record on the register the volume passing through the meter.

Manufacturers' literature fully describing the Pittsburgh Rotocycle Meter can be obtained by writing Pittsburgh Equitable Meter Company, Pittsburgh, Pennsylvania. Ask for Bulletin OG-125.

Improved Polished Rod Hanger

THE Advanced Petroleum Equipment Corporation, Houston, Texas, is placing on the market a polished rod hanger of new design, which, according to the manufacturers, is the



solution to many production problems.

In this hanger, the polished rod is firmly held by slips set in a bowl mounted on ball bearings. A rotating element keeps the rod turning continually while the well is pumping, which permits an even distribution of rod wear. The slip bowl is also supported on two rocker bearings that allow it to rock freely, compensating for any stressor strain resulting from the polished rod not traveling in a straight line.

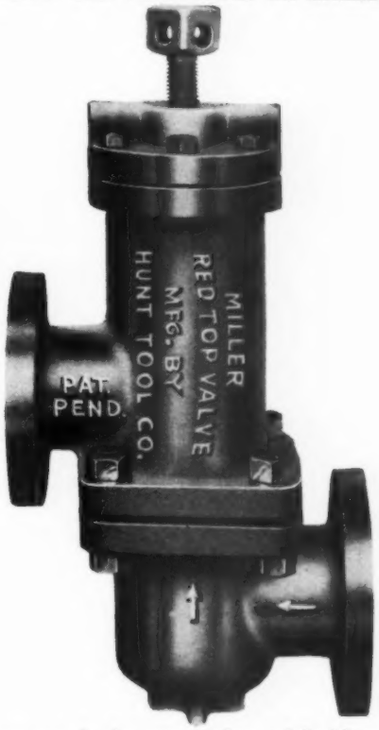
The accompanying illustration is a cross-sectional view of the rod hanger, showing the ball bearings, rocker bearings, slips, rotating element, polished rod, and other elements of construction.

Advantages claimed by the manufacturer include: the rocking action reduces the bend on the polished rod, thereby reducing wear on the stuffing box; constant rotation of sucker rods assures uniformly distributed wear on working barrel, and consequently longer life; any danger of the sucker rods backing-off at the couplings is positively eliminated; rotation eliminates any continual wear in one position on rods or in tubing.

This hanger is designed to operate efficiently in wells producing from maximum depths and has been tried and tested in the field by competent engineers, it is stated. Full details may be obtained by writing the manufacturer.

Blow-off Valve Designed to Provide Increased Safety

THE Hunt Tool Company, Houston, Texas, offers the new Red Top Blow-Off Valve, which is designed to provide increased safety and to eliminate hazards in blowing-off the boiler. This valve enables the fireman



to watch the water glass while blowing-off the boiler, the manufacturer states, and furthermore, supplies an incentive for keeping the water at the proper level — instead of working-off water, when at a high level, through the pump and engine.

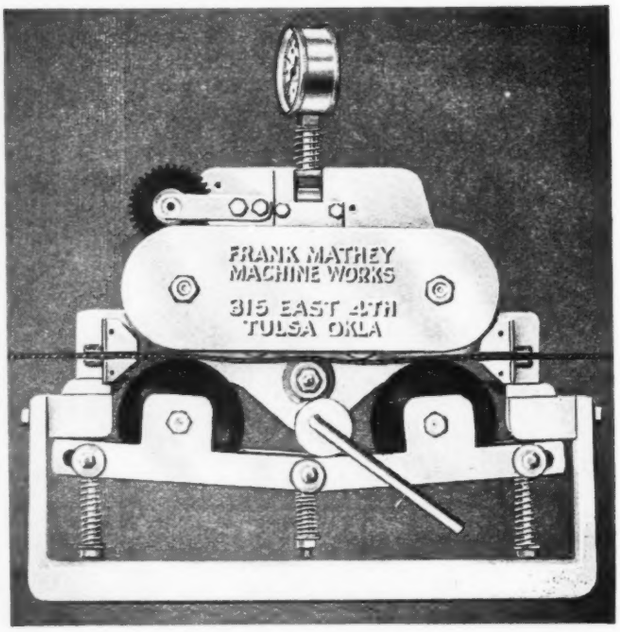
The valve is opened and closed by pressure from a 3-way pilot valve, directly connected through piping or copper tubing so that opening the pilot valve introduces pressure to the head of the blow-off valve, forcing it open. To close the valve, the pilot valve is closed, cutting off the pressure leading to the blow-off valve, and at the same time releasing the pressure in the blow-off valve head by venting it to atmosphere. This allows the blow-off valve to close.

The valve and seat are both reversible and renewable and can be changed easily. The valve body is of stainless steel, heavy, and virtually unbreakable, the makers assert.

For further information write the Hunt Tool Company.

Weight Indicator and Measure-Meter in One Unit

THE "Two-In-One" Indicator, announced by Frank Mathey Machine Works, Tulsa, Oklahoma, is a departure in measuring devices and weight indicators, the makers state, as it combines both machines into a single unit. The capacity of the machine is 10 lb. to 300 lb. and 10,000 feet. The "Two-In-One" Indicator contains a special aluminum body, is equipped with heat-treated rollers mounted on ball bearings, has hardened U-guide blocks, and achieves flexibility by tension springs and eccentric knee-action construction. The unit is a compact machine, only 17 in. long, 18 in. high, and 11 in. wide, weighs but 40 lb. and permits quick and easy portability. It is installed on truck or automobile and permits simultaneous reading of depth and weight, as the unit is always in full view of the operator. The machine is sold without weight indicator if the operator wants only a measuring device.



Cementing Collar

TO facilitate two-stage cementing jobs above the shoe, a float collar of new design has been developed by Baker Oil Tools, Inc., Huntington Park, California. This device is the Baker Duplex Cement Whirler Float Collar with Solid Bottom Baffle and the Metal "Petal" Basket. As it provides for placement of the cement through tubing or drill pipe, it is also particularly adapted to single-stage cementing jobs above the shoe if pressure is needed to break circulation or to place cement without putting a strain on the pipe. When a second stage is to be cemented above the collar, the new Baker Whirler Bridging Collar is placed in the string at the bottom of this upper stage.

As shown in the accompanying illustration, the Baker Duplex Cement Whirler Float Collar contains a ball-type back-pressure valve embedded in a concrete plug to form a solid baffle in the pipe below the valve. Leading from the valve chamber are ports, over the outer ends of which are baffle plates to direct fluid or cement slurry in a whirling motion as it is forced from the collar. The valve cage extends upward to the top of the concrete plug where it is equipped with left-hand, square threads into which the cementing string is screwed.

Cement is pumped through tubing or drill pipe, on the bottom of which is a Baker Circulation Joint and Bottom Sub, the latter having left-hand, square threads corresponding to those in the Duplex Collar. This cementing string is run and screwed into the collar after the liner or casing has been landed in the well. Circulation is broken and the cement pumped down the tubing, being directed through the whirler ports by the solid baffle below the ports. As soon as the cement is placed the cementing string is unscrewed and removed from the well, being flushed when disengaged to avoid any possibility of sticking.

For the second stage of cementing the Baker Whirler Bridging Collar is used. This consists of a whirler collar below which is a seat for a bridging ball. The seat is made of Bakelite and is embedded in a concrete plug through which is an opening large enough to pass the cementing string used to cement the lower stage. After the cementing string has been withdrawn upon completion of the lower stage, the bridging ball is dropped down the pipe and forms a bridge in the casing or liner, forcing the cement to pass out the whirler ports in the collar. Cement for this stage can be placed by the conventional plug method or by means of a cement retainer.

National 4-in. Type "GSB" Swivel

THE National Supply Company recently introduced an improved design of the well-known Ideal 4-in. Type "GS" Swivel. This new swivel is designated as the 4-in. Type "GSB" and is offered for drilling to moderate depth where a lightweight, low-cost swivel is desired.

The main bearing of the swivel is the cone-roller type and operates in an oil-bath. An improved feature is the tapered roller bearing mounted above the main bearing, which takes both the radial load and the up-thrust.

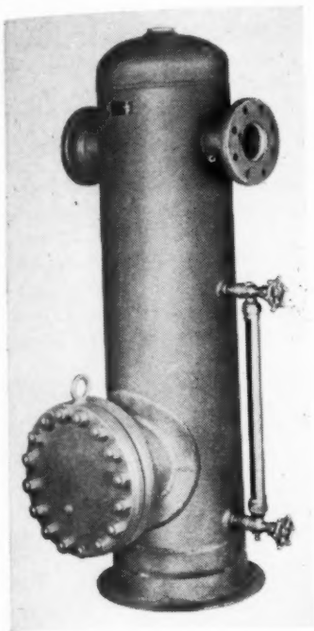
Elimination of packing problems is assured by the use of automatically adjusted packing for the wash pipe stuffing box and the lower body stuffing box, the makers assert. The sleeve is packed-off at the bottom of the body by two oil seals. The wash pipe packing is Ideal V-Ring Type Packing that is said to provide a positive seal against leakage.

The "GSB" Swivel has a 2¼-in. diameter weldless forged-steel bail that is attached to 3⅜-in. diameter trunnions that are formed integrally with the upper half of the two-piece body. The sleeve has a 2-in. diameter fluid passage, and a tapered thread at the lower end for the coupling.

This swivel can be supplied with a bracket for mounting a rubber bumper against which the elevator links may rest, reducing wear on the links.

Gas Well Separator

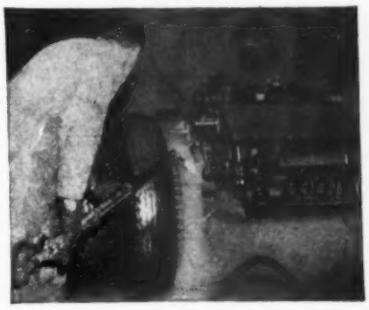
THE Peerless Manufacturing Company, Dallas, Texas, announces a new separator designed for high-pressure gas-distillate wells. Shells are seamless steel tubing, and have ellipsoidal heads. The Peerless Zig-Zag Vane Mist Extractor is used to complete the separation of entrained liquid. The liquid valve is internally mounted, has no packing glands or outside gadgets, and has a positive, weight-operated open-and-shut action. The intermittent action of the valve eliminates wire-drawing, and the valve and valve seat are stellited to eliminate wear. The valve mechanism is mounted on a 10-in. blind flange and nozzle that make a convenient clean-out opening. The separator is made in Standard or Code construction, and is said by the manufacturer to be efficient and low priced for the service.



Self-Lifting Oakite Steam Gun

A NEW steam gun developed to remove heavy accumulations of dirt, grease, and oil from all industrial machinery and equipment, is announced by Oakite Products, Inc., 14 Thames Street, New York, New York.

Although the new Oakite steam gun (patent applied for) incorporates the advantages of light weight and ease of use, the basic improvement is said to be its self-lifting feature. This gun automatically lifts the cleaning solution from floor level to a height exceeding ten ft. without the aid of pumps, injectors, means of gravity feed, or other auxiliary apparatus. All that is needed to operate this gun, the makers say, is steam and solution hoses, steam supply, and an open-top drum or other easily obtained open solution container.



The gun is manufactured in two sizes. The small unit, Model 384, is 3½ ft. in overall length and weighs 5¾ pounds. Equipped with an air-cooled handle, it is designed for cleaning automobile trucks, tractors, and similar types of equipment; and for cleaning machinery, equipment, floors, etc., in refineries. The larger unit, Model No. 385, which is 7½ ft. in overall length and weighs 13¼ lb., is designed for use on the heaviest steam cleaning operations where a long gun is required.

ARMSTRONG BROS. *Dependable* PIPE TOOLS

CHAIN TONGS

Jaws are drop forged from special steel, heat treated, hardened, tempered and tested. Handles forged from high carbon steel have both stiffness and "spring".

Flat Link Chains have proven strength—are proof-tested to ⅔ catalog strength (3,600 to 40,000 lbs.). Design improvements: jaws have increased bearing on bar and forged-in chain guides, large steel bolts, drop forged alloy steel shackle.

Better PIPE TOOLS—The most complete line made and each an improved tool

Solid Dies and Stocks
Adjustable Dies and Stocks
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Improved Simplex Emergency Jack

TEMPLETON, Kenly and Company, Chicago, Illinois, manufacturers of Simplex screw and ratchet jacks, have started production on an improved model of their No. 310 15-ton emergency jack, to be designated No. 310A. This new jack embodies ten improvements, several of which are said to be exclusive features. They include:

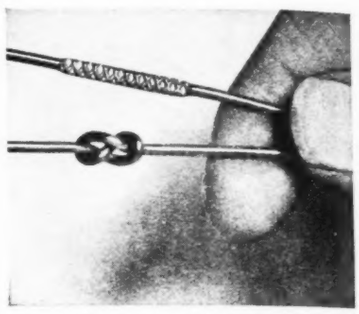
One inch greater lift, a total of 14 in.; 37 percent easier lifting; triple-toothed lifting and retaining pawls; greater overload capacity by actual hydraulic press test; jack base area increased 10 sq. in.; rack bar toe lift increased to more than 2 sq. in.; load

may be raised or lowered full limit of the rack bar when working at an angle; base locking hook can now be disengaged or engaged by the operator's foot; more convenient carrying handles, and greater rack bar gib slide bearing.

The No. 310A is supplied with a 5-ft. steel chain, a forged-steel auxiliary shoe, and a 5-ft. heat-treated lever bar.

G-E Magnet Wire

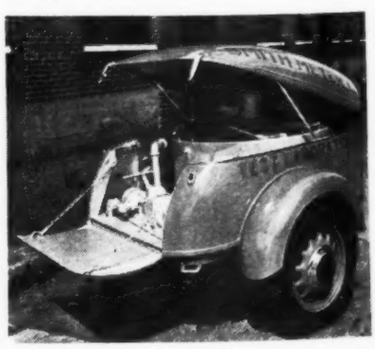
ELIMINATING the need for space-consuming protective coatings in many instances, Formex wire, a new magnet wire has been announced by General Electric Company, Schenectady, New York. The wire is insulated by a synthetic resin that is tougher



and more flexible than the conventional enamel coatings, it is stated. The resin is of the polyvinyl acetal type, whereas ordinary enamel coatings are composed of drying-oil resins. As Formex wire requires less space for insulation and protection, it gives the designer new opportunities to reduce the size of many products, the makers assert. Further, electrical properties are as good as those of ordinary enameled wires, it is stated, and tests show that Formex wire is considerably higher in resistance to abrasion and to the common treating solvents.

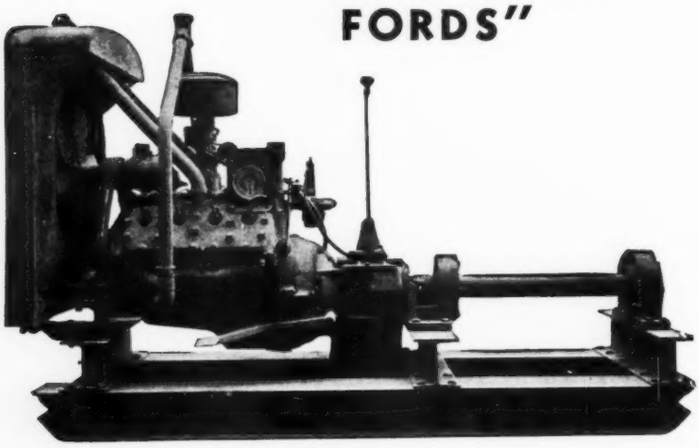
Portable Test Laboratory

WITH the introduction of a fleet of portable test laboratories, built into streamlined automo-



bile trailers, the Smith Meter Company, subsidiary of A. O. Smith Corporation, Milwaukee, Wisconsin, is providing

"We FEEL SAFER with FORDS"



GENERAL POWER CONVERSIONS of FORD V-8 ENGINES

FORDS
60 h.p.
85 h.p.
95 h.p.

..are safeguarding men, equipment, and investments throughout the oil fields, because they are an economical, sturdy source of dependable power. Engine and engine parts exchange plan, offered by every Ford dealer, assures a minimum of shut-down for repairs.

General Power Conversions are available in single, dual, or triple drive units for drilling, pumping, or generating purposes.

Write for Complete Catalog

GENERAL POWER, Inc.
Quapaw, Oklahoma Phone 64

a new service for users of petroleum meters. The trailers are stationed at strategic points throughout the country in order to give quick service at the point of installation to all kinds of meters, regardless of make, and to recalibrate Smith Meters when necessary.

Each trailer contains a large, accurately calibrated test tank of heavy-gauge steel. A large-neck intake provides for testing the accuracy of even the largest capacity meters. Hydraulic jacks level the trailer in two directions to insure accurate reading of the large test tank. A hose with nozzle attachment and a large-capacity, electrically driven pump are used to return the liquid to storage tank or tank truck compartment from which it is drawn in making the test.

Thermo-Safety Device

THERMO-SAFETY, manufactured by Bart Products Company, Bartlesville, Oklahoma, is a small device that is attached to engine or machine bearings, engine water jackets, compressor water jackets, chemical vats, water heaters, electric motors, ovens, roasters, and any other machinery in danger of overloading, to stop the engine or motor or warn of overheating by operating a signal system.

The Thermo-Safety Device is screwed into a hole drilled and tapped into the bearing, water jacket, or machine part to be protected. The device contains two electrical contacts normally held apart far enough to prevent sparking of the electrical circuit in which it is used.

An example of the use of the Thermo-Safety Device is the protection of engine bearings against over-heating. The device is installed in the bearing cap as near the journal working surface as possible. An insulated wire from the spark plug or magneto is attached to the terminal of the device. When the bearing becomes hot the device shorts the spark and stops the engine. If a Thermo-Safety Device is selected that has the proper temperature rating the engine will stop before damage is done to the bearing. When the engine has been placed in condition for service again a new device can be installed and the engine run in the usual manner. The device is vapor- and moisture-proof.

Improved Conveyor Belt

IMPROVED conveyor belt construction, embodying a feature designed to withstand severe service conditions, has been announced by the Mechanical Goods Division of United States Rubber Company, New York City.

The refinement, engineers explain, is accomplished by imbedding a special weave breaker-strip fabric in a heavy layer of soft white gum. This layer is inserted next to the belt carcass as an integral part of the belt cover, and provides a shock-absorbing cushion for the belt cover.

Because of its ability to absorb the shock of heavy impact this new type of construction increases the effectiveness of the cover in resisting the gouging, snagging, and other severe wear encountered in heavy service, it is stated. In addition to the increased cover wear thus obtained, its designers point out, extra protection is provided for the belt carcass owing to the ability of this white breaker-insert to withstand and cushion the blows of heavy material.

Good News Travels Fast . . .

FULLY PATENTED

. . . and rightly so, because the new COOK'S "TINIZED" Piston Rings, with their coating of soft, anti-friction metal over the **entire** wearing surface, make available for the first time, rings that are genuinely **NON-SCUFF** and **DOUBLE-QUICK SEATING.**

To operators as well as to builders, COOK'S "TINIZED" GRAPHITIC IRON Piston Rings offer the ultimate in ring **performance** and **economy. Specify them on your next order.** Full details in BULLETIN 385-E. Write for a copy — today.

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Piston Rings

"Shield-Arc" Arc Welders With Self-Indicating Control

A LINE of "Shield-Arc" welders, said to provide greater convenience and accuracy because of a new self-indicating dual continuous control, is announced by The Lincoln Electric Company, Cleveland, Ohio.

These welders have both job selector and current control calibrated and equipped with dials that indicate the type of work and the number of amperes for each setting. It is asserted that this development enables the welding operator to obtain highest quality welds and greatest possible welding

speed because he can vary both the slope of the volt-ampere curve and the amount of welding current independently and positively to suit every job.

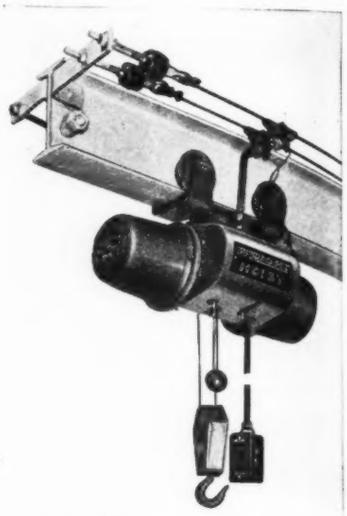
Another feature of this welder control is that both voltage control (job selector) and current control are continuous in operation. This design provides literally thousands of possible combinations of voltage and current. It is stated that this simplifies the setting of the control and accounts for an exceptionally wide welding range as to types of work, welding conditions, sizes of electrodes, and thicknesses of material.

Being continuous, the control can be advanced or retarded in increments as fine as desired.

This new line of Lincoln welders is available in a-c. and d-c. motor-driven types, belted or coupled type, and in gasoline-engine- and Diesel-engine-driven types, in all standard ratings.

Wright "Speedway" Electric Hoist

THE Speedway, a light-weight, low-cost wire rope electric hoist, has been added to its present line by the Wright Manufacturing Division of



the American Chain and Cable Company, Inc., York, Pennsylvania.

Hoisting capacities are 250 lb. to 750 lb. and hoisting speeds are 15 ft. to 43 ft. per minute. The Wright Speedway Electric Hoist standard construction includes fully enclosed ball-bearing motor, anti-friction bearings, cut alloy-steel spur gears, multiple-disk solenoid brake, push-button control, preformed hoisting cable, and many other quality features that make it suitable for production service, the makers assert.

It is made in three types for lug suspension, hook suspension, or mounted on trolley. Details will be sent on request.

DOUBLE PROTECTION *Against* HOSE FAILURES

When you specify GRIZZLY STEEL ARMORED ROTARY HOSE you are assured the best that engineering and manufacturing experience can produce. It is equally important to use couplings that will not detract from its built-in strength and flexibility.

Grizzly Rotary Hose Couplings and Grizzly Rotary Hose make an unbeatable combination that assures long, trouble free service and freedom from the usual hose failures around the connection. They not only hold the hose in a vice-like grip, without injury, but protect it throughout the full length of the coupling; permitting the hose to utilize its full strength under enormous pressures. They positively prevent slippage, breaking of plies, or other damage to the hose. Nipples cannot blow out. Hose failures and blowouts around the coupling are definitely reduced to minimum.

Ask your supply house for Bulletin No. 13-OF, and information relative to the Grizzly Rotary Hose Coupling Exchange.

E. M. SMITH COMPANY

600-650 South Clarence Street, Los Angeles, California, U.S.A.

Complete Stocks Maintained in Our Warehouses at: 1121 Rothwell Street, Section 16, Houston, Texas; 1008 S.E. 29th Street, Oklahoma City, Oklahoma. Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York City. Distributed by Leading Supply Companies.

Wheeling Steel Buys Interest In Atlas Supply

With the purchase of a large stock interest in the Atlas Supply Company, Muskogee, Oklahoma, by The Wheeling Steel Corporation, Wheeling, West Virginia, another major factor in the steel industry of the nation enters the oil well supply business on a basis that combines eastern manufacturing facilities in the production of steel products with a complete supply service to the petroleum industry.

Both Wheeling officials and J. H. McDonald, president of the Atlas Supply Company, announce that the Wheeling purchase involves no change in personnel, management, or policies of the Atlas Supply Company, except to strengthen the company's facilities for serving the oil industry.

The Atlas organization gives Wheeling a large staff of field engineers, salesmen, and supply stores, and branch offices at strategic points throughout the Mid-Continent area.

Atlas Supply Company has been serving the oil industry for 30 years, having been organized by McDonald in 1909, and he has been at the head of the company from its inception. J. R. Brooks, vice-president, has been associated with the company during all this time also.

Wheeling Steel Corporation has long served the oil industry with tubular products.

Sir Henri Deterding Passes Away

Sir Henri Deterding, former head of the Royal Dutch-Shell group, passed away February 4 at St. Moritz, Switzerland, where he had gone for a vacation. Death was the result of a heart attack.

Deterding was an outstanding figure in world financial affairs because of his role as guiding genius of the Royal Dutch Petroleum Company, of which he remained a director after retiring from the post of director-general.

He was born in Amsterdam in 1866 and at the age of 16 became the youngest employee of the Twentsche Bank, Amsterdam. Subsequently he was employed by The Netherlands Trading Society and was stationed in the Dutch East Indies. He resigned to join the Royal Dutch Oil Company and in 1900 became managing director of the Royal Dutch-Shell interests.

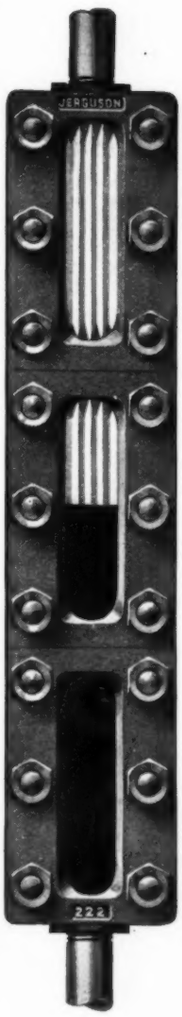
Carney Heads N. G. A. A. Convention Committee

Plans for the Eighteenth Annual Convention of the Natural Gasoline Association of America have been placed in exceptionally good hands, according to J. A. LaFortune, Warren Petroleum Corporation, president of the association. The convention is scheduled for May 3, 4, and 5 at the Hotel Tulsa, Tulsa, Oklahoma.

B. R. Carney, Shell Petroleum Corporation, Tulsa, has been appointed chairman of the convention program committee. Other members of the group are: E. L. Peck, Cities Service Oil Company, Bartlesville, Oklahoma; W. F. Fulton, United Gas Pipe Line Company, Houston, Texas; J. R. Jarvis, Lone Star Gasoline Company, Dallas, Texas; G. W. McCullough, Phillips Petroleum Company, Bartlesville, Oklahoma; Ray E. Miller, Hanlon-Buchanan, Inc., Tulsa, Oklahoma; and J. W. Vaiden, Skelly Oil Company, Tulsa, Oklahoma.

Present plans of the committee include emphasis on manufacturing problems and a number of papers on plant design and improved processes are already scheduled. The economic position of the natural gasoline industry with reference to changes in motor fuel quality resulting from the extended facilities of modern refineries will also be thoroughly reviewed.

JERGUSON



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for showing liquid levels in tanks, towers, stills, etc. Ideal for gasoline, kerosene, oil—no matter what the color of the liquid.

Easy to read because . . .

Empty space shows
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Dependable at high and low temperatures and pressures —that means effective protection to men and equipment.

There's a JERGUSON GAGE for your plant.

Jerguson Gages are best
By every real test.

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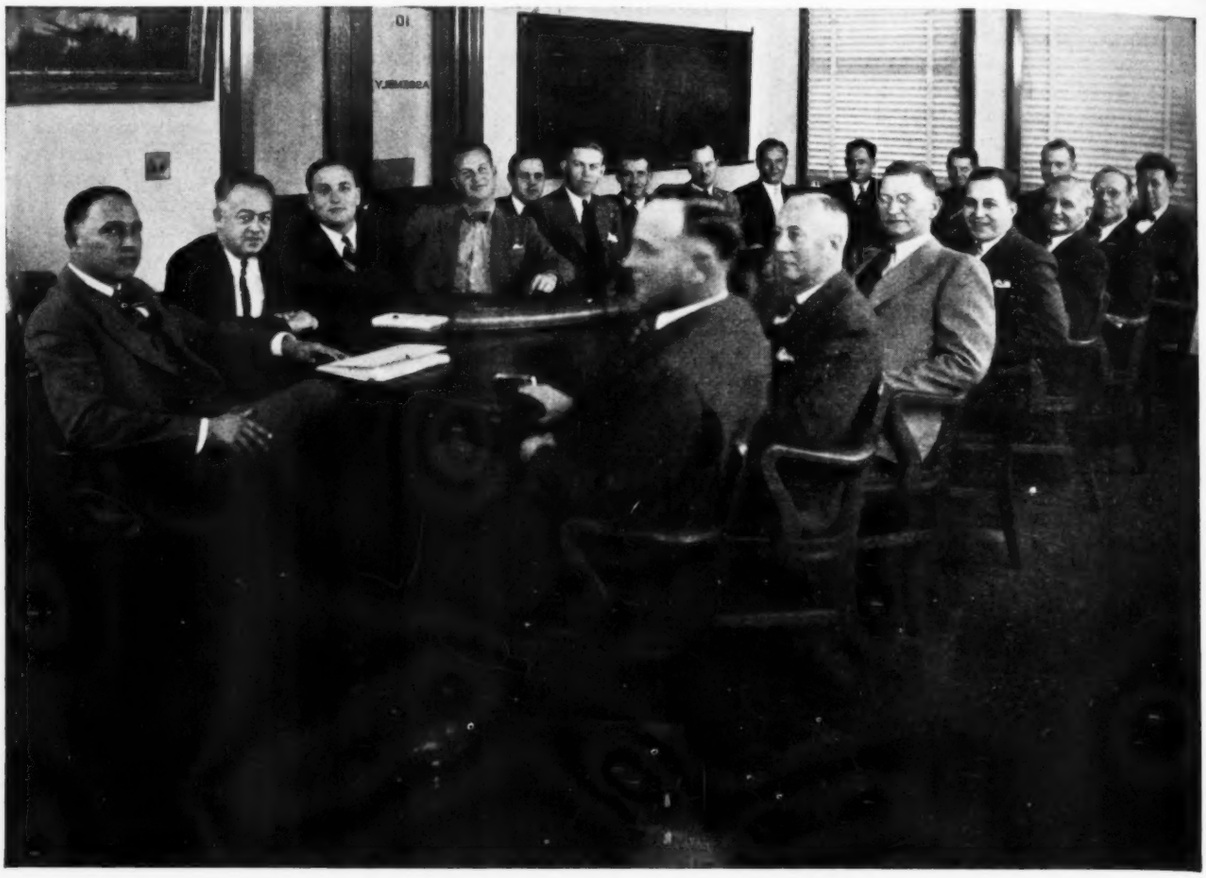
89 FELLSWAY
SOMERVILLE MASSACHUSETTS

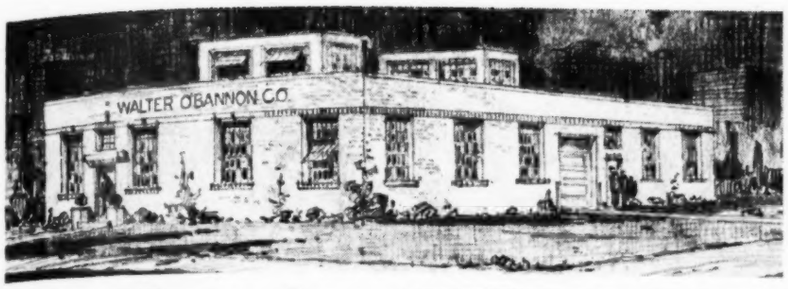
Axelson Sales Meeting

Members of Axelson Manufacturing Company's California sales force recently met for a two-day session at the main plant in Los Angeles. Under the direction of Alvin Zwerneman, California sales manager, various field services and distribution problems were discussed. Zwerneman said this meeting was only one of a number scheduled for 1939, all designed to make Axelson's service to the oil operators more nearly complete and more far-reaching.



Beginning at the extreme left and reading around the circle are: Alvin Zwerneman, Ray M. Humphreys, M. Ray Conger, Howard F. Donley, Glynn Williams, Willard F. Goertz, Stanley Morrish, Clinton J. Huyck, Philip E. Humphreys, Howard Cowan, W. Harry Getsinger, William R. Jennings, Edwin F. Green, Milfred J. Parker, Abraham G. Haglund, Clayton E. Rose, Harlan S. Kelley, William H. Jackson, Elmer J. Phillips

Guiberson Executives and Employees Hold Annual Meeting in Dallas



Walter O'Bannon Constructs Branch Plant

The Walter O'Bannon Company, manufacturers of oil-pumping equipment, has recently completed the construction of a branch plant at 2500 West Vickory Boulevard, Fort Worth, Texas.

Henry Pullman to South America

Henry Pullman of Baker Oil Tools, Inc., Huntington Park, California, has left for Toronto, Canada, from where he will go to New York. About March 1 he will proceed by plane to South America, visiting the fields in Trinidad, Venezuela, Colombia, Ecuador, Peru, and the Argentine.

Baker to Executive Post With Lucey Firm

LOUIS WALDO BAKER

Franklin E. Bernsen, president of Lucey Products Corporation, Tulsa, Oklahoma, has announced the appointment of Louis Waldo Baker to the position of assistant to the president in general charge of the firm's oil well supply business. His headquarters will remain in Tulsa.

Baker went to Tulsa in 1927 as a banker and joined the personnel of the First National Bank and Trust Company. He held that position until 1930 when he became assistant to the treasurer of the Lucey organization. In 1935 he was elected a vice-president of the supply firm and in December, 1938, became a member of the board of directors. He now occupies the position recently vacated by John A. Chapman who became associated with the Frick-Reid Supply Corporation.

Baker is a native of Bridgeport, Illinois. After completing his education, he became associated with the Farmers State Bank of Lawrenceville, Illinois, from which post he went to Tulsa 12 years ago.

THAT NEXT WELL

. . you plan to put on the pump can be a first-class nuisance, or it can go along smoothly, depending on how you equip it. We have made pumping equipment for 20 years —nothing else. We know the producers' problems from two decades of personal contact and co-operation.

So why don't you tell us about the well, and we'll tell you exactly what you can expect from the right JENSEN Unit. These jacks are not expensive, but they get the job done with less trouble and for less money than anything else yet devised.

JENSEN BROTHERS MANUFACTURING CO.

. . . . . *Coffeyville, Kansas*

EXPORT OFFICE . . . 136 LIBERTY STREET • NEW YORK, N. Y.

Thoroughly Modern . .

• Link-Belt anti-friction roller and babbitted bearing transmission units and the complete line of Link-Belt positive drives—silent and roller chain drives, speed reducers, and variable speed transmissions—afford better ways of solving transmission problems. Among the results you get are lower power consumption—less lubrication needs—the elimination of much of that day-in-and-day-out maintenance—and greater dependability. Send for catalog. Link-Belt Company, Chicago, Indianapolis, Philadelphia, Dallas, Houston, Los Angeles, New York, or any of our other offices, located in principal cities. 7518-A

Hilton Heads Sales Staff of Rector Organization

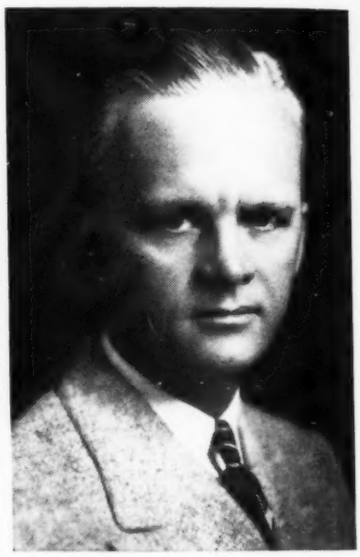
Rector Well Equipment Company, Fort Worth, Texas, announces the recent appointment of L. D. "Lew" Hilton as sales manager. From Fort Worth he will cover the entire oil country, working with Rectorhead and Rectorseal representatives in active districts throughout the United States.

With Cameron Iron Works since 1930, until joining the Rector organization, Hilton has had a wide experience in the oil industry. Beginning in California fields he became field superintendent of Pan American Petroleum Company in 1916, four years later he became associated with a syndicate engaged in townlot drilling in the Los Angeles Basin fields, during which time he represented the operators and the Oil Division of the State Mining Bureau. He entered the equipment business in 1926, and has been responsible for the development of several well known products in wide use today.

LEW HILTON

C. W. Thornhill on South American Tour

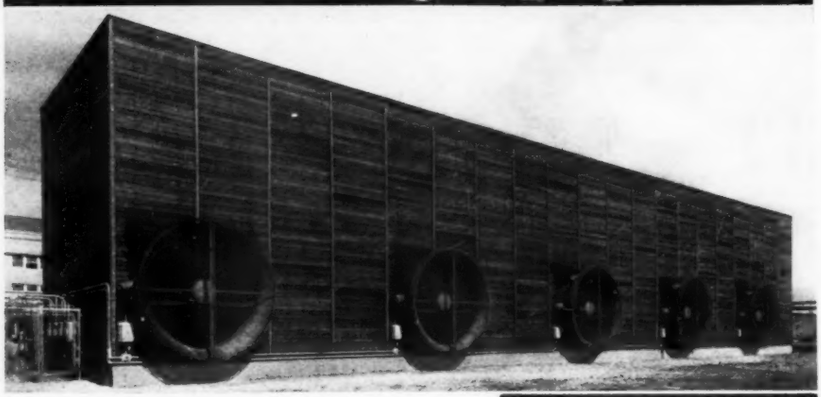
Chas. W. Thornhill, vice-president, Thornhill-Craver Company, Houston, Texas, left Miami, Florida, by plane



CHAS. W. THORNHILL

early in February, the first leg of an extended tour of South American fields that will require several months. The first stop was Barranquilla, Colombia, which country he will travel by air, water, and rail to reach all points of important activity, thence to Ecuador, Peru, and Chile. His schedule calls for his return to Maracaibo from the northern interior of the continent within two months and he then will proceed through eastern Venezuela to Port of Spain, Trinidad. Here he will be met by Mrs. Thornhill, who will accompany him to Rio De Janerio and Buenos Aires, from which point Thornhill will fly to Patagonia, in the extreme lower section of the Argentine Republic.

MARLEY the COMPLETE Line of
Water Cooling Equipment



New Models at New Savings!

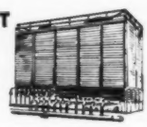
Values Up! Prices Down!

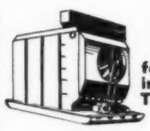
The Marley line for 1939 offers the accumulated advantages of the longest and broadest experience at building heat-transfer equipment plus important features developed during 1938 by a veteran research and engineering staff. Yet prices have been reduced.

The wide diversity of types, a few of which are shown here, permits the efficient, economical solution of any water cooling problem. It will pay you to call in your nearest Marley engineer whatever your needs may be.

FORCED DRAFT TOWERS
For Refineries, Natural Gasoline Plants, Etc.

INDUCED DRAFT TOWERS
For Gas Compressor stations, Recycling Plants, etc.





PORTABLE UNITS
for Cooling Engines in Oil Drilling and Temporary Pumping Service.

SPRAY TOWERS
For Pipe Line Pumping Stations and Similar Services.

SPRAY PONDS
for Refineries and Many Other Kinds of Heavy-Duty Service.

The MARLEY Company
Fairfax and Marley Roads, Kansas City, Kansas

Founder of Emsco Will Continue to Be Active

E. M. SMITH

E. M. Smith, founder and former president of the Emsco Derrick and Equipment Company, who recently disposed of his own and interests of others to the Youngstown Sheet and Tube Company for more than $2,500,000, announces that he will continue to be active in the oil equipment industry and will retain his many contacts with oil people throughout the world.

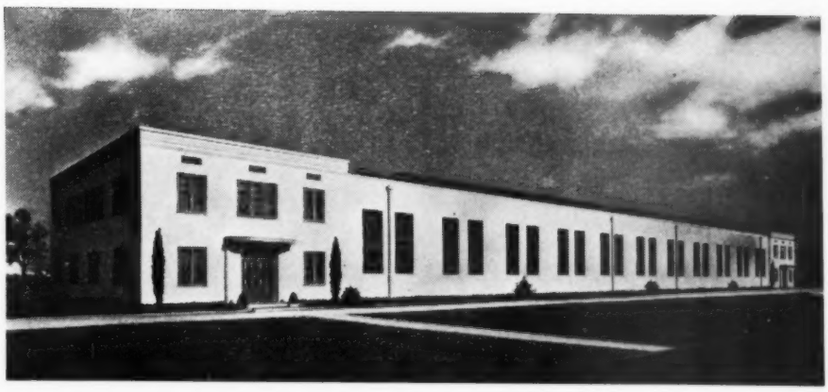
For the present, "E. M." will be at E. M. Smith Company's branch office at 1121 Rothwell Street, Houston, Texas, where the company maintains warehouse facilities with complete stocks of the full line of Grizzly products for distribution to the Mid-Continent and Gulf Coast oil fields.

Smith Meter Company Builds New Plant

The new plant of the Smith Meter Company has been completed at 5140 E. Leneve Street, East Los Angeles, California, and is now occupied by the company, manufacturers of a complete line of rotary-action, positive-displacement type petroleum meters.

The new structure is of steel and stucco construction. Scientifically improved artificial lighting is provided for use when needed and window lights and skylights of special glass give efficient diffusion of daylight for the precision work essential to the construction of Smith Meters. General offices and research division are housed in an adjoining two-story portion of the new building.

In addition to this large new unit, the company will continue to maintain its meter laboratory at the old Fishburn Street address in Los Angeles, where, according to present plans, complete machine-shop facilities will be retained for the building of experimental meter models.



The Smith Meter Company is a subsidiary of the A. O. Smith Corporation, Milwaukee, Wisconsin.

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THE SPECIAL ILLINOIS BASIN NUMBER
To Be Published In March

This issue will feature—

Drilling Practices
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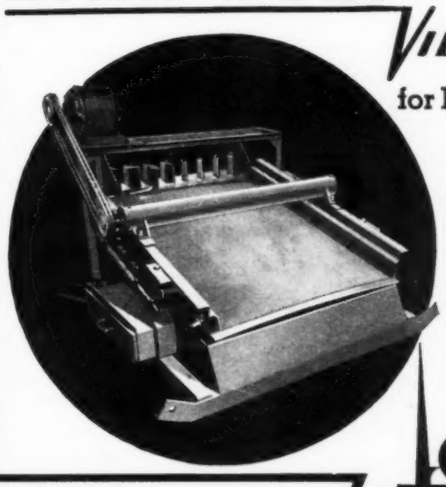
P. O. Box 1589 Dallas, Texas

LINK-BELT
VIBRATING SCREEN
for Reconditioning Rotary Mud



● The Link-Belt Screen is recognized as the most efficient and lowest cost method of effectively reconditioning rotary mud. Its many exclusive features, such as fine mesh stainless steel screen cloth, rubber cushioned; adjustable feed; enclosed vibrator unit; unitized collecting tank; self-contained drive, etc., have made it the screen preferred by most drilling contractors and operators. Made in two sizes for shallow, medium and deep well drilling. Send for Folder No. 1772.

Link-Belt Company, Philadelphia, Houston, Dallas, Los Angeles, Indianapolis, Chicago, New York. Distributors in all fields. 7542

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LINK-BELT *Vibrating* SCREEN

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Won't You Admit

. . IF YOU'RE A PRODUCTION MAN, that the important consideration with oil well pumps is not what they are made of, but whether or not they will put the oil in the tanks economically?

You want results — and that's where we fit into your picture.

To get the results you're after we burn plenty of "midnight oil" designing and building O'Bannon pumps right — then spend days in the field testing them.

That's why, when you install O'Bannon Pumps, you are betting on a sure thing!

O'Bannon Pumps not only raise your oil, but lower your lifting costs!

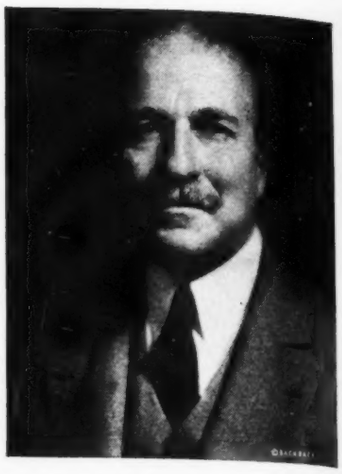
•

WALTER O'BANNON COMPANY
Tulsa Ft. Worth

O'BANNON PUMPS

Elected Johns-Manville Vice-President

Robert W. Lea, who has been elected a vice-president of Johns-Manville Corporation, manufacturers of building materials and industrial products. Before taking the J-M post, in which he will be in charge of finance, Lea was president of the West Virginia Coal and Coke Company, of which he will remain a director.



H. M. Wall Elected Head Wall Rope

At the annual meeting of Wall Rope Works, Inc., Harold M. Wall was elected president of the company. William F. Wall continues as chairman of the board, and Waldo Reiner as secretary-treasurer.

Harold M. Wall succeeds to the office held by his brother, the late C. Frederick Wall.

Regan 121"
NARROW TYPE
TYPE (G)
TRAVELING BLOCK

6 Sheaves—500 Tons Capacity
Weight 11,500 lbs.

5 Sheaves—400 Tons Capacity
Weight 9,800 lbs.

(Dead Load Capacities)

Overall height—156⅜"
Overall depth—56"

Widths:
5 Sheaves—19½"; 6 Sheaves —24½"

Your inquiry is invited. Ask for descriptive literature. See 1939 Composite Catalog.

Regan
Forge & Engineering Co.
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Mid-Continent Office—1502 Maury St., Houston, Texas
Okla. and Kansas Rep.—Bovaird Supply Co., Tulsa and Wichita
New York City Office—17 Battery. G. R. Woods, Rep.

Trade Literature

CLIMAX MOLYBDENUM, 500 Fifth Avenue, New York City, has just issued a booklet on molybdenum steels suitable for use in oil production equipment. It is primarily of interest to drilling contractors and others who come in practical contact with alloy steels.

KOPPERS COMPANY, American Hammered Piston Ring Division, Baltimore, Maryland, has just issued the fourth edition of its Engineer's Piston Ring Handbook, a practical manual giving recommended types, specifications, and applications of piston rings for machine designers and operators. The publication, which is handsomely bound, illustrated, and printed, will be sent free upon request to designing or operating engineers.

AN ELABORATE NEW BROCHURE entitled, "The Sun Rises on an Advanced Nixon Surface Control Gas-Lift System," has just been issued by Wilson Supply Company, Houston.

This new booklet describes certain advancements in the design and operation of the system. It is comprehensive in its treatment of the system's operation and success.

A copy of the book may be obtained by writing Wilson Supply Company, Houston, Texas.

THE JARECKI MANUFACTURING COMPANY has a new bulletin describing the Jarco Roller Pull Rod Carrier that explains the construction and use of this carrier for supporting surface pull rods in oil field service. Copies can be obtained by writing the Jarecki Manufacturing Company, Tulsa, Oklahoma, for Bulletin No. 5.

Added Space Provided for Houston Show; Safety Work Will Be Featured

A new steel and concrete annex built adjacent to the Coliseum at Houston, Texas, will provide the required additional space that has been found necessary to accommodate the exhibits at the 1939 Oil-World Exposition, to be held from April 24 to 29. This new building will have a floor space in excess of 90,000 sq. ft. and is so situated that its main floor will be an extension of the main floor of the $1,337,000 Coliseum that was completed last year. In addition there will be a ground floor exhibiting area on the same level as the outdoor exhibits. The greater facilities thus provided for the 1939 Show have enabled the management to contract more space than for the previous exposition.

Petroleum Industry Safety Engineers who have completed plans for Oil-World Exposition Safety Program and Meetings: J. J. Delahide, B. F. McDonald Company; H. B. Williams, Pan American Petroleum Company; Ed G. Lenzner, general manager, Oil-World Exposition; J. B. McAtee, United Gas System; T. S. Maffitt, Jr., Houston Oil Company; F. P. Werner, American Petroleum Company; G. M. Kintz, U. S. Bureau of Mines, Dallas; R. H. Horde, Shell Petroleum Corporation; H. L. Rankin, Gulf Oil Corporation; Vic Hayslip, Humble Oil and Refining Company; and C. A. Miller, The Texas Company

The importance of safety work will be an outstanding feature of the exposition. An extensive program covering the various phases of safety practice that are achieving such excellent results in field and plant will be given in the Convention Hall of the Coliseum on Thursday, April 27, and Friday, April 28, and will bring to the thousands of oil men in attendance speakers of authority from various parts of the country. This program will include not only technical and practical discussions on safety practices but will also provide interesting demonstration work and display of safety equipment.

As a means of furthering the education of petroleum engineering students, a program of student papers also has been arranged for presentation at the exposition. Ed G. Lenzner, general manager of the Oil-World Exposition, has advised that the exposition management is providing cash prizes for the best papers read at this meeting, which will take place in the Convention Hall of the Coliseum on the evening of Wednesday, April 26.

The Student Program will be under the supervision of a sub-committee of the drilling and production committee and consists of Professors Howard E. Degler, University of Texas, chairman; Benjamin C. Craft, Louisiana State University; J. H. Pound, Rice Institute; Harry H. Power, University of Texas; and Harold Vance, Texas A. & M. College.

These 5 ADVANTAGES explain the superiority of the B-M-W Tex Type Working Valve

1—Unexcelled for bad sand conditions;
2—5 to 13 per cent more fluid handled;
3—Slippage is practically nil;
4—Minimum frictional drag in the tube;
5—Runs are exceptionally long because of its durability.

Ideal for common barrels. (For insert pumps use TEX TYPE Plunger Fittings.) It is an assembly of a large number of Composition Rings separated by metal washers. In effect it is a grooved seal plunger, made from rubber and fabric, which readily adapts itself to the tube in which it works. It has the advantages of both cups and metal plungers without the disadvantages of either. Complete data on request. See our advertisement in the "Composite Catalog."

AT SUPPLY STORES

B-M-W Products are obtainable at supply stores: ● TEX TYPE Plunger Fittings and Valves; ● ADMORE Insert Pump Anchors; ● NEILSON Tools (Safety Sucker Rod Hooks, Tubing Hooks, Rod Elevators, Sucker Rod Sockets, etc); ● BALLS and SEATS (Made for every pumping service); ● ADMORE Liner Barrels; and ● COLLINS Belt Clamps.

SOMETHING NEW

If you have not read about the new B-M-W TOWER TYPE BALL & SEAT and the new B-M-W TWO-WAY NON-MAGNETIC CROWN—we shall be glad to send complete data.

BRADFORD MOTOR WORKS INC.
OIL WELL SUPPLIES
BRADFORD, PA. — TULSA, OKLA.

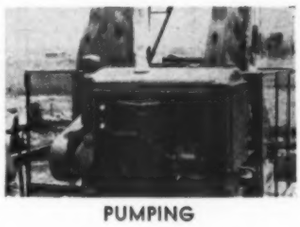
Famous the world over for Quality and Efficiency

ENSIGN NATURAL GAS AND BUTANE-PROPANE Carburetion Equipment

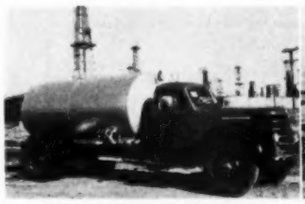
ENSIGN Natural Gas Carburetion Equipment has proved its superior quality and efficiency in the Oil and Gas industries for years.

The superiority of ENSIGN Equipment for the carburetion of Butane-Propane fuels (a comparatively recent development) is just as pronounced.

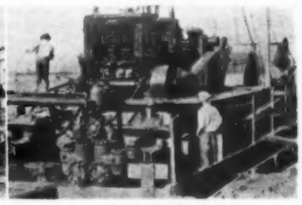
For oil well drilling, servicing, pumping and transportation, be sure your engine units are ENSIGN-equipped!



PUMPING



TRANSPORTATION



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THE FINAL TEST of a DITCHING MACHINE

comes when you figure the total cost of the completed trench—time, labor, investment, depreciation, operating and maintenance expense. Such a test leads logically to the purchase of a Buckeye for jobs that call for trench narrow or wide, deep or shallow.

We will be glad to show you how our figures work out on your particular kind of job. Investigate Buckeye Ditchers before you buy ditching equipment this year.

BID THE Buckeye WAY ask for our operation data before you bid

THE BUCKEYE TRACTION DITCHER CO.
FINDLAY, OHIO, U. S. A.

DOWN goes your wrench expense with the rugged guaranteed RIDGID

No housing repairs with this famous all-alloy pipe wrench—and that means practically no wrench upkeep expense at all. Bend pipe with a RIDGID, twist it—you won't harm the housing. Adjusting nut won't bind, always spins easily in all sizes, 6" to 60". Sure action jaws of chrome molybdenum, handy pipe scale on full-floating hook jaw, heel jaw replaceable. Powerful comfort-grip I-beam handle—a safe efficient wrench in any use or emergency, as millions of users can tell you. Made also in End Pattern for pipes against flat surfaces. For real wrench satisfaction and economy, buy RIDGID at your Supply House.

THE RIDGE TOOL COMPANY, ELYRIA, O.

RIDGID PIPE TOOLS

MEETINGS

California Natural Gasoline Association—March 2, Richfield Building, Los Angeles, California.

Indiana Independent Petroleum Association, Spring Convention and Refiners' and Suppliers' Exhibit—March 14, 15, and 16, Hotel Severin, Indianapolis, Indiana.

American Petroleum Institute Division of Production, Southwest District—March 16 and 17, Plaza Hotel, San Antonio, Texas.

Western Petroleum Refiners Association, Annual Meeting—March 20, 21, and 22, Plaza Hotel, San Antonio, Texas.

American Association of Petroleum Geologists—March 22, 23, and 24, Oklahoma City, Oklahoma.

American Chemical Society—April 3, 4, 5, 6, and 7, Baltimore, Maryland.

American Petroleum Institute Division of Production, Eastern District—April 4 and 5, William Penn Hotel, Pittsburgh, Pennsylvania.

American Petroleum Institute Division of Production, Pacific Coast District—April 11, Biltmore Hotel, Los Angeles, California.

American Petroleum Institute Division of Production, Mid-Continent District—April 18 and 19, Skirvin Hotel, Oklahoma City, Oklahoma.

Oil-World Exposition—April 24, 25, 26, 27, 28, and 29, Houston, Texas.

Petroleum Industry Electrical Association—May 3, 4, and 5, Rice Hotel, Houston, Texas.

Petroleum Electric Supply Association—May 3, 4, and 5, Houston, Texas.

Natural Gasoline Association of America—May 3, 4, and 5, Tulsa, Oklahoma.

American Petroleum Institute, Mid-Year Meeting—May 15, 16, 17, and 18, Roosevelt Hotel, New Orleans, Louisiana.

Pennsylvania Grade Crude Oil Association—June 15 and 16, Hotel Hershey, Hershey, Pennsylvania.

American Society for Testing Materials, Annual Meeting—June 26, 27, 28, 29, and 30, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

International Petroleum Exposition—May 18, 19, 20, 21, 22, 23, 24, and 25, 1940, Tulsa, Oklahoma.

Mission Representatives Assigned New Territory

Allan Nelson, formerly having his headquarters at Tyler, Texas, from where he served as the Mission Manufacturing Company representative for East Texas, has recently been transferred to Oklahoma City, phone number 8-7612. From there he will serve Kansas and that part of Oklahoma north of Ada.

Fred S. Price, representative for the Mission Manufacturing Company, having headquarters in Wichita Falls, Texas, phone number 8006, will serve in addition to his present territory, that part of Oklahoma south of Ada.

Oil Well Drilling Company Moves Offices

The Oil Well Drilling Company has moved its offices from the Liberty Bank Building to 606 Field Street, Dallas, Texas. G. C. Conrad is president of the company and W. E. Cunningham secretary.

Gotkool
WATER CANS
& COOLERS
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Book Reviews

Modern Plastics, Third Annual Handbook, Catalog, and Directory Number. Published by Breskin and Charlton Publishing Company, 122 East 42nd St., New York. 304 pages, October, 1938. Price, $2.00.

This issue of Modern Plastics includes a review of the most recent developments in plastic materials, processes, processing equipment, and products, and a discussion of the different types of plastics, their principal characteristics, and the optimum methods of processing. The refinery technologist should find some useful ideas therein.

* * *

Practical Oil Geology, by Dorsey Hager. Published by McGraw-Hill Book Company, Inc., 330 West 42nd St., New York. 5th edition, 466 pages, 1938. Price, $4.00.

The last previous edition of this work was published in 1926. Improvements in geophysics and petroleum engineering since that time have necessitated changes and additions. Two new chapters have been included, one pertaining to geophysics and one to paleontology. The number of references added to the bibliography seems disproportionately small. Nevertheless, this edition surpasses in usefulness the earlier editions.

* * *

Pipe Corrosion and Coatings, by Erick Larson. Published by American Gas Journal, 53 Park Place, New York. 460 pages, 1938. Price, $2.50

In this volume are collected, coördinated, and explained in understandable terms the various theories of corrosion and of pipe protection.

The object throughout the book has been to explain theory in a way that the average operator could understand; to show how theory should be applied in practice, and to outline specific procedure for determining the corrosiveness of soils, for making corrosion surveys of pipe lines, and for applying protective coatings.

* * *

U. S. S. Carilloy Steels. Published by the Carnegie-Illinois Steel Corporation, 208 South La Salle St., Chicago, Illinois. 214 pages, 3 charts, 1939. Price $1.00.

This book includes a study of the hardening of steel, based both on practical and theoretical behavior. It is also a complete handbook on alloy steels. It contains a list of steel-making elements, their commercial uses, their effect in steel, and the types of steel containing them. There are complete lists of SAE alloy steels, their analyses, and some of their commercial applications.

Chapters on the iron-carbon diagram and its use for hardening and annealing operations, heating practice and heating furnaces for hardening and annealing, and quenching practice and the physical properties of different grades of alloy steels after quenching in various ways are included.

G. E. Everett to A. P. I. Staff

G. E. Everett, head of the public relations department of the Western Petroleum Refiners Association, left Tulsa for New York on February 10 to join the public relations staff of the American Petroleum Institute.

Everett has been with the refiners' association since 1936 after having been secretary of the Low Cost Roads Association in Kansas City, which was organized as a subsidiary of the W. P. R. A. to promote greater use of asphalt and road oil for highway building.

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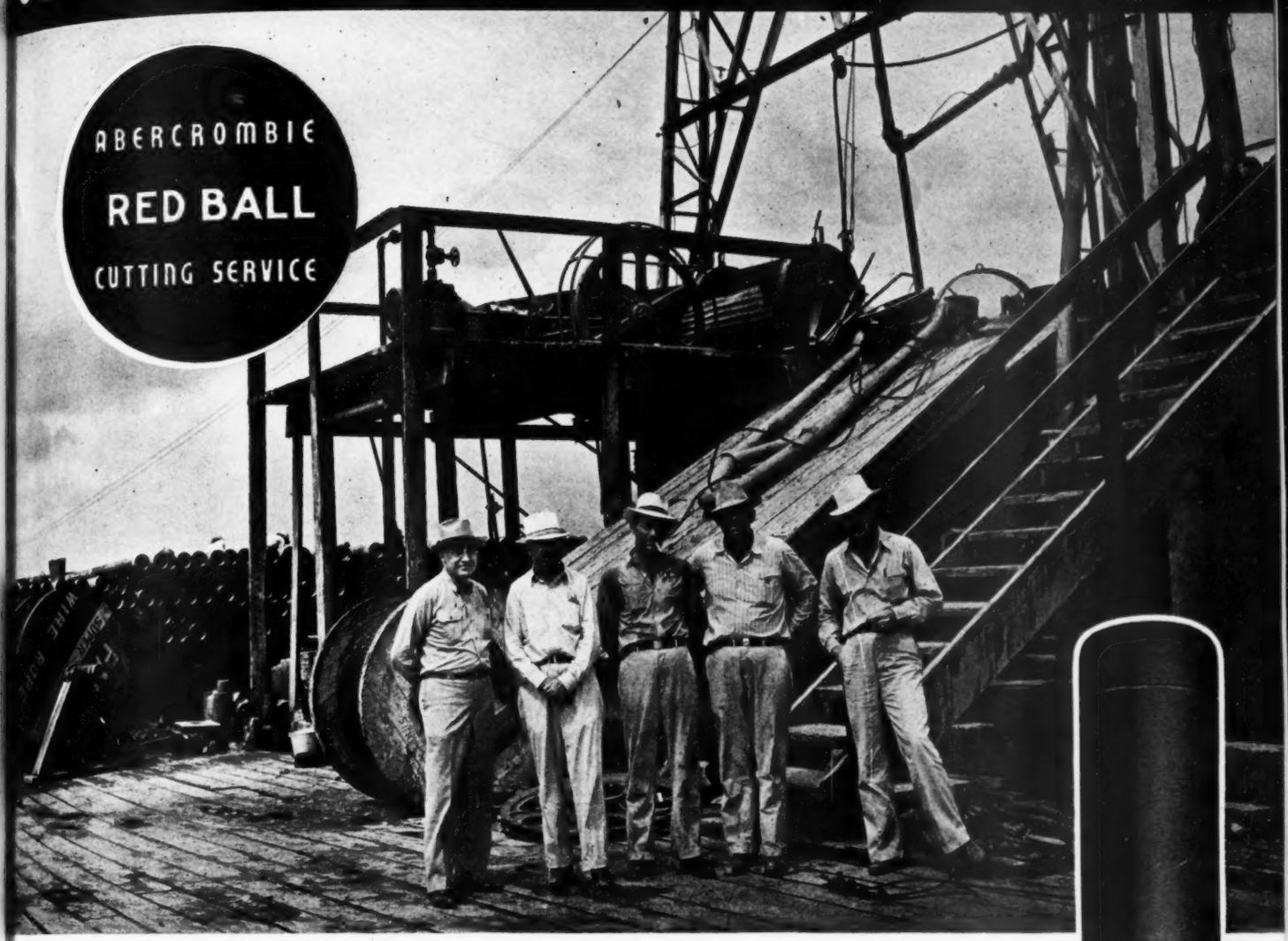

The well: Pan American-Barnsdall's Community B-2. The men (left to right) E. R. Turner, general manager, and Ira Walker, district Superintendent, Pan American; C. P. Necessary and Clyde Long, tool pushers; and Bob Prentice, Abercrombie RED BALL Cutting Service.

We got a tough one when we were called on this Valentine, Louisiana, job . . . 4½" drill pipe stuck "tighter'n a drum" from 2353 feet to 9045 feet.

Bob Prentice, RED BALL Cutting Service Operator stationed at Houma, Louisiana, washed over and made 20 cuts (note depths at right) averaging 334 feet per cut, or a total of 6692 feet . . . and had the hole cleaned to bottom in 27 days. It's an example of the many holes saved for successful completion regularly by this proven cutting service, despite the handicaps of today's extreme depths.

DEPTHS OF THE 20 CUTS:

2353'	6982'
2949'	7288'
3590'	7561'
3651'	7773'
4261'	7986'
4812'	8158'
5238'	8404'
5728'	8618'
6214'	8829'
6643'	9045'

Abercrombie Outside Cutter, shown at right, feeds the knives smoothly into the cut automatically by screw feed propelled by rotation of the tool, preventing gouging. There is no upward strain on the cutters.

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